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FINAL REPORT

CONTRACT ARDS-477

SMALL, LIGHT-WEIGHT ALTITUDE TRANSMISSION EQUIPMENT

APRIL, 1963

Project No. 108-28-1D

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By

HAZELTINE CORPORATION
HAZELTINE ELECTRONICS DIVISION
TECHNICAL DEVELOPMENT CENTER
INDIANAPOLIS, INDIANA

FINAL REPORT

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This report has been prepared by Hazeltine Corporation, Hazeltine Electronics Division, Technical Development Center, for the systems Research and Development Service, Federal Aviation Agency, under Contract ARDS-477. The contents of this report reflect the views of the contractor, who is responsible for the facts and accuracy of the data presented herein, and do not necessarily reflect the official views or policy of the FAA.

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ABSTRACT

Report 6107 describes the design and development of the Small Light-Weight, Altitude Transmission Equipment (SLATE) for the Federal Aviation Agency Aviation Research and Development Service. The development was performed by the Hazeltine Corporation Technical Development Center under Contract ARDS-477.

Both SLATE I and SLATE II operate at a transmitter frequency of 1090mc and receiver frequency of 1030mc. SLATE I reply codes include any of 33 altitude codes plus an IDENT pulse. SLATE II reply codes include any one of 33 altitude codes in Mode C or codes 00 through 77 (64 codes), plus the IDENT pulse in Mode 3A. Both SLATE modes incorporate additional circuits to provide echo suppression and side lobe suppression.

Major problem areas were encountered in the development of an adequate, low-cost altitude transducer, and in the development of the transmitter oscillator. A pressure cell-controlled servo system was adopted as an altitude transducer. An adequate transmitter oscillator was developed using a miniature triode. Other development problems concerning pulse width variation and receiver sensitivity and selectivity were surmounted.

In conclusion, all specified performance characteristics were met or exceeded. The equipment size could be reduced by using miniature components. The increased cost, however, would offset the weight and space savings incurred.

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SECTION I

INTRODUCTION

This report describes the design and development of Small, Light-weight, Altitude Transmission Equipment (SLATE). The development was performed by the Hazeltine Corporation Technical Development Center for the Federal Aviation Agency, Aviation Research and Development Service under Contract ARDS-477. Conclusions and recommendations regarding the development of this equipment may be found in Section VI of this report.

SECTION II

THEORY OF OPERATION

A. GENERAL

This section contains the theory of operation for the Hazeltine Small Lightweight Altitude Transmission Equipment (SLATE), Types I and II. A detailed block diagram indicating the signal flow, is shown in figure 1 for SLATE I and figure 2 for SLATE II. The theory is based on the block diagrams and on the schematic diagrams (figures 3 and 4).

Interrogation signals at a frequency of 1030mc are received at the antenna of the SLATE. These interrogation signals are applied through an r-f preselector to the mixer. The interrogation signals are heterodyned with the 1090mc local oscillator signals in the mixer. The resulting difference frequency of 60mc is applied to the i-f strip for amplification. The 60mc signal is then detected, amplified, and processed in the video stages. The processed video is applied to the Mode C and Mode 3A decoder circuits. If an altitude interrogation is received, the Mode C decoder will produce an output pulse. If an identification interrogation is received, the Mode 3A decoder will produce an output pulse. Depending upon whether the interrogation is Mode 3A or C, the identification code selector or the altitude transducer will control the encoding of the reply pulse train, respectively. The encoding circuits generate the reply pulse trains with the information pulse positions either vacant or filled. The encoder outputs are applied to the modulator where the reply pulses are amplified to a level sufficient to pulse the transmitter oscillator. The 1090mc output of the transmitter is connected to the antenna through the preselector. The preselector provides r-f selectivity for the receiver and provides isolation to protect the mixer crystal diode from the transmitter power.

The SLATE has additional circuits to provide echo suppression and side lobe suppression. Echo suppression is accomplished by desensitizing the receiving section of the SLATE during the period immediately following a pulse. Side lobe suppression (SLS) is a means of suppressing a reply from an aircraft located in a side lobe of the ground antenna pattern. A ground installation equipped with SLS transmits a pulse 2 microseconds after the first interrogation pulse. The SLS pulse is transmitted at the same frequency as the interrogation pulses, but an omnidirectional antenna is used and the field intensity of the SLS signal is held down to the field intensity of the strongest side lobe

of the interrogating antenna. An aircraft located in the main lobe of the interrogating antenna receives an interrogation in which the interrogation pulses are greater in amplitude than the SLS pulse, but an aircraft located in a side lobe receives an interrogation in which the SLS pulse is equal to or greater than the amplitude of the interrogation pulses. If the SLATE receives the SLS pulse in the proper time and amplitude relationships with the first interrogation pulse, the reply to the interrogation is suppressed.

B. R-F SECTION

1. Antenna

The receiving and transmitting antenna is a quarter-wave stub with a short sleeve impedance matching section.

2. Transmitter

The transmitter circuit employs a GE Z2172 miniature triode (V1101). The triode is operated as a grid-pulsed oscillator at a frequency of 1090mc. The transmitter is housed in one end of the microwave assembly.

3. Preselector

The preselector is a three-section filter contained in the microwave assembly between the antenna input post and the mixer output post. The preselector isolates the receiver from the transmitter, so that the same antenna can be used for both transmission and reception. Receiver r-f selectivity is also provided by the preselector.

C. I-F SECTION

1. Mixer

The diode mixer (CR2001) is located on the i-f strip printed circuit board. The mixer diode produces the 60mc signal which is the difference frequency resulting from heterodyning the 1030mc received signal with the 1090mc local oscillator signal. The detected signal is applied to the base of Q2001, the first i-f amplifier stage.

2. I-F Amplifier

The i-f amplifier consists of five transformer-coupled, transistor stages (Q2001 through Q2005) which are connected in the common emitter configuration. The bandwidth of the i-f amplifier is approximately 8mc.

3. Sensitivity Control

The reply triggering sensitivity can be adjusted by varying potentiometer R2101. The potentiometer varies the collector to emitter bias on the first and fourth transistor amplifier stages in the i-f strip (Q2001 and Q2004).

4. Automatic Overload Control

The d-c voltage obtained from the automatic overload control (AOC) circuit in the video section is applied to the emitters of i-f amplifier stages Q2002 and Q2003. The emitter currents, and therefore, gain of these two transistors is reduced when the transponder reply rate exceeds the desired rate.

D. VIDEO PROCESSING SECTION

1. Video Detector

The output of the i-f amplifier is transformer-coupled to the video detector diode (CR2002). The resulting video signal is applied to emitter follower Q2006.

2. Echo Suppression

Q3101 provides both echo suppression action and output pulse width standardization. Capacitor C3102, in combination with R3106, causes the output of Q3101 to be differentiated, limiting the output pulse width to 0.3 microsecond. Additionally, during the duration of the input pulse, a charge is stored in capacitor C3102. At the end of the input pulse the charge stored in C3102 is discharged through R3106. The time constant of C3102 and R3106 is adjusted to provide the proper charge decay rate. In this manner, desensitization of Q3101 continues at a decreasing amplitude until the voltage on C3102 reaches a value equal to the quiescent emitter voltage of Q3101. Only the initial portion of the exponential discharge produced by C3102 and R3106 is used. Hence the discharge rate is approximately linear. The gain of Q3101 is reduced for periods up to 15 microseconds duration after each pulse, due to the discharging of the R-C network. The amount of gain reduction and the gain recovery time are functions of the signal level and can be controlled by potentiometer R3103 in the base bias network of Q3101. This action reduces the effect of signal echoes and is used for signal level comparison purposes to determine whether the side lobe suppression (SLS) signals should cause suppression.

3. Video Amplifier

The video amplifier consists of five capacity-coupled, common emitter, amplifier stages (Q3102, Q3103, Q3104, and Q3105). Video inhibiting is accomplished by applying a voltage obtained from the SLS multivibrator through Q3106 to the emitter of Q3105.

4. Delay Line Driver

The positive interrogation pulses from the last video amplifier (Q3105), and the subsequent negative pulse from the encode pulse amplifier are applied to the delay line driver. The delay line driver stage is a complimentary emitter follower that will operate with either positive or negative input pulses. The circuit consists of Q3107, a pnp transistor which is utilized for negative going pulses in parallel with Q3108, an npn transistor which is utilized for positive-going pulses.

E. DECODING SECTION

1. Side Lobe Suppression Decoder

The SLS decoder has an effective output pulse only if a legitimate SLS pulse is received and only if this pulse has sufficient amplitude to pass through the echo suppression circuit. If the SLS pulse is more than 9db below the first interrogation pulse, the desensitizing action of the echo suppression circuit will cause the amplitude of the SLS pulse to drop below the level necessary to trigger the SLS gate generator. The decoder also determines by time measurement whether the SLS pulse is legitimate. AND 1 obtains one of its two inputs from the 0-microsecond tap on the delay line and the other from the 2-microsecond tap on the delay line. If the SLS pulse is legitimate, the first interrogation pulse will be in coincidence with the SLS pulse at AND 1, and there will be an output pulse from AND 1. This triggers the SLS gate generator.

2. Mode C Decoder Circuit

The Mode C decoder circuit produces an output pulse only when a Mode C interrogation is received. The circuit accomplishes this decoding by applying the interrogation pulses from the 0-microsecond tap on the delay line to one input of AND 3 and the interrogation pulses from the 21-microsecond tap on the delay line to the other input of AND 3. When a Mode C interrogation (21-microsecond pulse pair) is received and applied to the input of the delay line, the two pulses will appear in coincidence at the input of AND 3. AND 3 will produce an output pulse unless an inhibit pulse is present from AND 1, the SLS decoder.

3. Mode 3A Decoder Circuit (Exists only in SLATE II)

The Mode 3A decoder circuit produces an output pulse only when a Mode 3A interrogation is received. The circuit accomplishes this decoding by applying the Mode 3A interrogation pulses (8-microsecond pulse pair) from the 0-microsecond tap on the delay line to one input of AND 2 and from the 8-microsecond tap to the other input of AND 2. The two pulses will appear in coincidence at the input of AND 3. Because the two input pulses arrive in coincidence, AND 2 will produce an output pulse, unless an inhibit pulse is present from AND 1, the SLS decoder.

F. GATE GENERATORS AND REPLY CIRCUITS

1. SLS Gate Generator

The SLS gate generator produces a signal to disable the video amplifier section and the decoder(s) whenever a legitimate SLS pulse is received or whenever the SLATE initiates a reply. The SLS gate generator is a monostable multivibrator that obtains its triggering signal from OR 1 (CR3102 and CR3103). One of the two OR 1 inputs is obtained from SLS AND 1, while the other input is the differentiated output of the mode gate emitter follower (Q3114). The SLS gate output pulse, which has a duration of approximately 35 microseconds, is applied to Q3106, the video suppression amplifier, and Q3115, the decoding suppressor. Upon receiving the SLS gate, the video suppression amplifier applies an inhibit voltage to the video amplifier, and the decoding inhibitor applies an inhibit voltage to the decoder(s). With the video amplifier and the decoder(s) inhibited, there can be no further decoding.

2. Mode C Gate Generator

The output pulse from AND 3 is used to trigger the Mode C gate generator, which consists of Q3109 and Q3110 in a monostable multivibrator configuration. Upon being triggered, the multivibrator produces a positive d-c level at the collector of Q3213 and a negative d-c level at the collector of Q3214. The multivibrator remains in the unstable state for approximately 28 microseconds, at which time it returns to the stable state.

3. Mode 3A Gate Generator (Exists only in SLATE II)

The output pulse obtained from AND 2 is used to trigger the Mode 3A gate generator which consists of Q3301 and Q3302 in a monostable multivibrator configuration. Upon being triggered, the multivibrator produces a positive d-c level

at the collector of Q3302 which is applied to OR 2, and a negative d-c level at the collector of Q3301 which is applied to AND 4. The multivibrator remains in the unstable state for approximately 28 microseconds, at which time it returns to the stable state.

4. Mode Gate Emitter Follower

SLATE I: The positive gate signal from the Mode C gate generator is applied through the mode gate emitter follower to the SLS gate generator (Q3111 and Q3112), the encode pulse amplifier (Q3113), the clock gate (Q3201), and the automatic overload control (Q3116 and Q3117).

SLATE II: OR 2 is utilized to produce an output gate when either the Mode C or the Mode 3A gate generator has been triggered. The output of OR 2 is applied to the circuits used for either Mode C or Mode 3A, namely the SLS gate generator (Q3111 and Q3112), the encode pulse amplifier (Q3113), the clock gate (Q3201), and the automatic overload control (Q3116 and Q3117).

5. Automatic Overload Control

The automatic overload control circuit (Q3116 and Q3117) keeps a running account of the reply rate, and reduces the sensitivity of the receiver section when the rate exceeds the predetermined limit set by potentiometer R3401. Pulses received from the mode gate generator are integrated and a d-c level is established at the base of transistor Q3116. Since the pulse width is fixed, the d-c level is proportional to the transmitter reply rate. Q3116 and Q3117 form a two stage d-c amplifier, the output of which is used to control the gain of i-f amplifier stages Q2002 and Q2003. When the reply rate approaches the "turn down" value, the gain of the i-f amplifier is reduced to discriminate against weaker signals and to limit the number of replies. This prevents damage to the transmitter tube.

6. Encode Pulse Amplifier

The mode gate is differentiated and applied to Q3113, the encode pulse amplifier. The output of this common emitter amplifier is a pulse which is applied through the delay line driver to the delay line.

G. REPLY TRAIN ENCODING

1. Mode C Encoding

A negative encoding pulse is applied to the input of the delay (DL1) by the delay line driver (Q3107 and Q3108). The pulse travels down the delay line, and as it

passes F1, the first tap, it delivers the first framing pulse to OR 5. This pulse passes through OR 5, AND 4 (since AND 4 is also receiving a gate from the Mode C gate generator), and OR 3, to the read pulse amplifier (Q3209). This is the first framing pulse for the reply pulse train. As the encoding pulse travels on down the delay line toward the terminating resistor (R3154) it passes taps A_1, A_2, A_4, B_1, and B_4 and delivers a pulse to each one as it passes. Taps A_2 through B_4 apply pulses to their corresponding AND circuits (AND circuits 14 through 18). The five transducer circuits A_2 through B_4 are also connected to the AND's. Pulses will appear at the output of those AND's enabled by the transducer. The transducer enables the AND's by applying ground.

A pulse appearing at the output of any of these AND circuits is automatically a part of the reply pulse train, because the pulse passes on through OR 5, AND 4 (since AND 4 is also receiving a gate from the Mode C gate generator), and OR 3 to the read pulse amplifier.

As the encode pulse passes the eighth delay line tap (F2) on its way to the termination, it delivers a framing pulse to OR 5. This pulse appears in the pulse train because it also passes through OR 4, AND 5, and OR 3 to the read pulse amplifier.

2. Mode 3A Encoding (exists only in SLATE II)

Mode 3A encoding is accomplished in much the same manner as Mode C encoding. The first and last framing pulses (F_1 and F_2) are passed through OR 4, AND 5, and OR 3 to appear in the pulse train at the read pulse amplifier. Since the Mode 3A gate generator has applied a gate to one side of AND 5, any pulses from OR 4 will be passed through AND 5 until the encoding period has expired. Taps A_1 through B_4 apply pulses to their corresponding AND circuits (AND circuits 7 through 12). The six code select switch circuits A_1 through B_4 are also connected to the ANDs. Pulses will appear at the output of those ANDs enabled by the code select switch. The code select switch enables the ANDs by applying a ground. The pulses produced at the outputs of the ANDs pass on through OR 4, AND 5, and OR 3 to appear in the pulse train at the read pulse amplifier (Q3209).

3. IDENT Hold

Upon depressing the IDENT button located on the control panel, a base-to-emitter bias of +12 volts is applied to Q3210, a pnp transistor. Q3210 is switched off, producing a negative IDENT gate at the collector. Q3210 does

not return to its normal condition upon releasing the IDENT button because C3212 maintains the cutoff bias on the base of this transistor for a period of from 10 to 20 seconds, depending upon the setting of R3402.

4. IDENT Encoding in SLATE I

The IDENT gate from Q3210 is applied through emitter follower Q3211 to AND 13 and the base of Q3214, the altitude inhibit transistor. The IDENT pulse from the IDENT tap on the delay line can pass through AND 13 as long as the IDENT gate is being held on by Q3210. The output of AND 13 is passed through OR 5, AND 4, and OR 3 to the read pulse amplifier. The IDENT gate applied to Q3214 switches this transistor off when in turn opens the common return lead from the altitude transducer. Opening this lead eliminates the information pulses from the replies.

5. IDENT Encoding in SLATE II

The IDENT gate from 3210 is applied through emitter follower Q3211 to AND 13. The IDENT pulse from the IDENT tap on the delay line can pass through AND 13 as long as the IDENT gate exists. The pulse from AND 13 is passed through OR 4 to AND 5. If the reply is Mode 3A, the pulse passes through AND 5 and on through OR 3 to the read pulse amplifier. Since the output of AND 13 is not applied to OR 5, the IDENT pulse cannot appear in a Mode C reply.

6. Read Pulse Amplifier

The pulse train from OR 3 is amplified by the read pulse amplifier (Q3209) and applied to AND 6.

H. PULSE TRAIN SHAPING AND TIMING

1. Clock Gate

Transistor Q3201, the clock gate, amplifies and inverts the mode gate signal from the mode gate emitter follower.

2. Clock

The clock is a temperature-compensated L-C oscillator that operates at 689.655kc. Transistor Q3202 is the oscillator transistor. During a reply, the negative d-c level from the clock gate back biases CR3201. This removes the clamp signal from the base of Q3202. The energy stored in L3201 causes oscillations to start instantly. When the reply has been completed, a positive d-c level from the clock gate passes through CR3201 (now forward

biased) to the base of the oscillator, clamping the oscillator in the full-on condition. The positive d-c level is held on the base of the oscillator until another reply is initiated.

3. Clock Pulse Amplifier

The clock pulse amplifier is Q3203 and Q3204. The output of the oscillator is passed through Q3203, an emitter follower, and through a half-wave rectifier CR3202. Transistor Q3204 amplifies only the negative half of the output signal. The input signal is of amplitude sufficient to cause heavy clipping of the amplified pulses. In this manner, the stage converts the 689.655 half sine wave into a pulse train. (Repetition rate = 1.45 microseconds.)

4. AND 6

AND 6 is a coincidence circuit which is used to integrate the accurate timing qualities of the clock pulses into the reply pulse train. One input to AND 6 is from the clock pulse amplifier Q3204, and the other is from the read pulse amplifier. The timing of the reply train pulses as they leave AND 6 is solely determined by the clock pulses. This is because the clock pulses are considerably narrower than the pulses of the reply train and there must be coincidence between the two for AND 6 to produce output.

5. Reply Pulse Amplifier

The reply pulse train from AND 6 is amplified and shaped in the reply pulse amplifier. The amplifier consists of two common emitter amplifiers Q3205 and Q3206 and an emitter follower which drives the modulator, Q3207.

I. MODULATOR

The amplified reply pulse train from emitter follower Q3207 is applied to the modulator stage Q4001 through potentiometer R4004. CR4001 shunts the input to the modulator transistor to prevent the signals from going positive. L4001 differentiates the pulses into the modulator to improve the rise time of the pulses out of the modulator.

J. TRANSMITTER

The transmitter is a tuned-grid tuned-plate oscillator which uses a GE Z2172 miniature triode (V1101). The tuned-grid circuit, the tuned-plate circuit, and

the antenna coupling post are located in the microwave assembly Z1001. The stage has output only when it receives a pulse from the modulator. The d-c bias voltage presented to the grid during a pulse from the modulator is determined by the setting of R4002. When adjusted properly, the transmitter has output r-f pulses of 32 watts (peak minimum) at 1090mc frequency (±3mc).

K. POWER SUPPLY

The power supply is a d-c to a-c to d-c converter. Transistors Q5001 and Q5002 switch the primary of the power transformer, T5001, at approximately 1500cps. Silicon diodes are used as full-wave rectifiers in the secondary circuits of the transformer to supply the various d-c voltages to the transistor circuits, to the transmitter, and to the receiver local oscillator. R-C networks are used to provide filtering and isolation. A series regulator (Q5003) in the primary circuit of the transformer, provides compensation for variations in the d-c input voltage. A zener diode, CR5001, provides a reference voltage for the series regulator, resulting in a constant d-c source for the switching circuit.

Short circuit protection is provided by the inherent characteristics of the converter and the choice of components.

A-C heater power for the vacuum tubes in the transmitter and receiver local oscillator is supplied by a separate secondary winding of T5001.

High voltage for the transmitter oscillator is obtained from a separate secondary winding of transformer T5001 and the bridge rectifier configuration (CR5002 through CR5005). The power relay (K5001) is controlled by the STDBY-OFF-NORMAL switch. The relay switches the power to the power supply.

L. ALTITUDE TRANSDUCER

Utilizing the mechanism of a sensitive altimeter, the transducer receives basic pressure-altitude information which is then converted to digital form by a brush and disc type encoder. A contact follower servomechanism is utilized between the altimeter mechanism and the brush and disc encoder. The altimeter mechanism controls the position of a rocking arm contact with respect to two servo control contacts. (See figure 5.) If the rocking arm contact makes electrical contact with one of the servo control contacts, the servo motor immediately turns the code disc such as to center the rocking arm contact between the servo control contacts. Hence, the servomechanism is a zero seeking device which operates with mechanical amplification. The servomechanism draws approximately one watt from the aircraft power source.

The transducer reads out the information by producing various open and closed switch conditions. The number of tracks on the encoder disc total six and are identified as the A_1, A_2, A_4, B_1, B_2, and B_4 tracks. The altitude/code table of paragraph N indicates which track(s) are providing a closed circuit for any given altitude. Examples of altitude encoding can be found in figure 6. The altitude information is referenced to 29.92 inches of mercury and is not adjustable.

M. CODE SELECTOR SWITCH (EXISTS ONLY IN SLATE II)

The code selector switch consists of two stacked 8-position wafer switches with concentric shafts. Each of the concentric shafts has a dial calibrated from 0 through 7. The proper number and location of information pulses in a Mode 3A reply can be readily determined by knowing that the outer dial always indicates the sum of the subscripts of the first three information pulses desired (A pulses), while the inner dial always indicates the sum of the subscripts of the last three information pulses (B pulses).

The combinations of these two switches equals 2^6 or 64 codes. Note that although the code numbers are 00 through 77, there are no 8's or 9's, hence there are only 64 codes. Examples of identification encoding can be found in figure 6.

N. ALTITUDE/CODE TABLE

The following table indicates the code number and which information pulses are present for any altitude between -1,250 and 14,750 feet above sea level.

Pressure Altitude (feet)	A_1	A_2	A_4	B_1	B_2	B_4	Equivalent Identity Code Number
-1250 to -750							00
-750 to -250						x	04
-250 to +250					x	x	06
+250 to +750					x		02
+750 to +1250				x	x		03
+1250 to +1750				x	x	x	07

Pressure Altitude (feet)	A_1	A_2	A_4	B_1	B_2	B_4	Equivalent Identitiy Code Number
+1750 to +2250				x		x	05
+2250 to +2750				x			01
+2750 to +3250			x	x			41
+3250 to +3750			x	x		x	45
+3750 to +4250			x	x	x	x	47
+4250 to +4750			x	x	x		43
+4750 to +5250			x		x		42
+5250 to +5750			x		x	x	46
+5750 to +6250			x			x	44
+6250 to +6750			x				40
+6750 to +7250		x	x				60
+7250 to +7750		x	x			x	64
+7750 to +8250		x	x		x	x	66
+8250 to +8750		x	x		x		62
+8750 to +9250		x	x	x	x		63
+9250 to +9750		x	x	x	x	x	67
+9750 to +10250		x	x	x		x	65
+10250 to +10750		x	x	x			61
+10750 to +11250		x		x			21
+11250 to +11750		x		x		x	25

Pressure Altitude (feet)	A_1	A_2	A_4	B_1	B_2	B_4	Equivalent Identity Code Number
+11750 to +12250		x		x	x	x	27
+12250 to +12750		x		x	x		23
+12750 to +13250		x			x		22
+13250 to +13750		x			x	x	26
+13750 to +14250		x				x	24
+14250 to +14750		x					20

SECTION III

DEVELOPMENT PROBLEMS

A. GENERAL

Two major problem areas were encountered in the design and development program:

1. Development of an adequate, low-cost altitude transducer.

2. Development of the transmitter oscillator.

B. ALTITUDE TRANSDUCER

Hazeltine sub-contracted the development of an altitude transducer to the Kollsman Instrument Corporation. The initial approach to the altitude transducer investigated by Kollsman consisted of the use of a shadow mask assembly driven directly by the pressure cell mechanism and interposed between light sources and a series of photocells. This approach was discontinued after the following problems were discovered:

1. The unit would have been expensive to manufacture because of the precise machining necessary to produce the required encoding accuracy.

2. The unit was potentially unreliable because of the light bulbs used as light sources and because of the photocells.

3. The unit was sensitive to roll moments because of the relatively large mass of the shadow mask assembly on the shaft.

4. The unit forced unnecessary complication of the encoding circuits in the receiver-transmitter unit because of the low on-to-off ratio of the photocell resistance.

The second method of obtaining the required altitude transducer investigated by Kollsman was a simple servo system controlled by the pressure cell and driving a conventional brush and disc encoder. The results obtained with this unit were adequate and the method was adopted. Test data is included in Section IV.

C. TRANSMITTER OSCILLATOR

During the early stages of the contract, Hazeltine developed a tuned-grid, tuned-plate oscillator using a conventional seven-pin miniature triode as the active element. An integrated r-f assembly was designed containing the local oscillator, r-f preselector filter, and transmitter oscillator. Miniature triodes for this transmitter were developed by two tube manufacturers. Extensive tests on many tubes indicated, however, that only one of the two tube types considered was satisfactory. The required peak power output of 32 watts was easily obtained.

D. OTHER PROBLEMS

1. Pulse Width Variation

Pulse width variation with temperature was a problem in early designs. This problem was solved by employing a thermistor in the modulator circuit to vary the drive to the transmitter tube with variations in temperature. Early transmitters also exhibited frequency instability with humidity. This instability was found to be the result of moisture trapped in one of the dielectric elements in the transmitter. The element would break down under the high field conditions and a change in the output frequency resulted. Different materials in a different shape were used to solve this problem.

2. Receiver Sensitivity and Selectivity

Several methods of achieving the required receiver sensitivity and selectivity were investigated. The required -61dbm sensitivity was not attainable with a low-cost crystal video system without r-f preamplification. The cost of the r-f preamplifier, together with the cost of the crystal video system would have exceeded the cost of the superheterodyne receiver that was employed. The 5-stage i-f amplifier employed in the equipment provides more than adequate gain and selectivity. A four-stage amplifier was investigated; however, this amplifier would have had marginal sensitivity and the cost reduction would not have been significant. The selectivity of the unit also would have been marginal but within specification requirements.

A two section preselector was also considered as a cost-reduction measure. Two sections were found to provide inadequate image rejection; therefore, the three-section unit was employed.

Although the parts cost is not affected by the requirement for a sensitivity of -61dbm, instead of the normal -74dbm of full range transponders, the test and alignment time is reduced. Reduction in manufacturing labor costs will, of course, reduce the total cost of the unit.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

All specified performance characteristics were met or exceeded. The technical characteristics were met in the manner originally proposed, with the major exception of the altitude transducer. The altitude transducer originally proposed could have been developed; however, the advantages of the method finally used dictated the change.

There is a relatively minor difference in the complexity and cost between the SLATE I and SLATE II receiver-transmitter circuits. The additional components for the SLATE II are on printed circuit board number 3300 and consist of three transistors, sixteen diodes, eleven capacitors, and 42 resistors.

In addition, a control box is required for SLATE II, to allow selection of the Mode 3A reply codes.

The differences in size, weight, and power consumption between SLATE I and SLATE II are insignificant. Slightly more aircraft panel space is required for the SLATE II control box.

It is also concluded that a low cost conventional miniature triode will provide the required low transmitted power of the SLATE equipment, and that, with additional development, these tubes and associated circuits could be designed to yield r-f power levels of nearly 100 watts peak.

It is also concluded that the receiver sensitivity of -61dbm required in SLATE specifications does not significantly reduce the number of components in the receiver as compared to one of -74dbm sensitivity. The skirt selectivity of -40db at ±25mc, rather than that of -60db at ±25mc of full-range transponders, does not materially affect the receiver design or the required number of components. The present i-f amplifier design is economical from both the material and labor cost standpoints. The relaxed specifications do effect a minor cost reduction from the test and alignment standpoint.

Recent advances in transistor technology have produced transistors that will oscillate at frequencies above 1Gc. These devices could probably be used in place of the local oscillator vacuum tube. To date, the cost of the high-frequency transistors is many times that of the vacuum tube and is excessive for this application.

In conclusion, the following statements apply to the results of this development:

1. There is relatively little difference in the SLATE I and SLATE II equipment, with the exception of the control box.

2. The lower range of SLATE as compared to full-range transponders has relatively small effect on the cost of the receiver section.

3. The range reduction does affect a reduction in cost of the transmitter section.

4. The equipment could be made significantly smaller by using miniature components (delay line, etc.). However, the increase in cost resulting from the use of such components would more than offset savings in weight and space and thus defeat the intent of the development program.

SECTION V

DIAGRAMS AND ILLUSTRATIONS

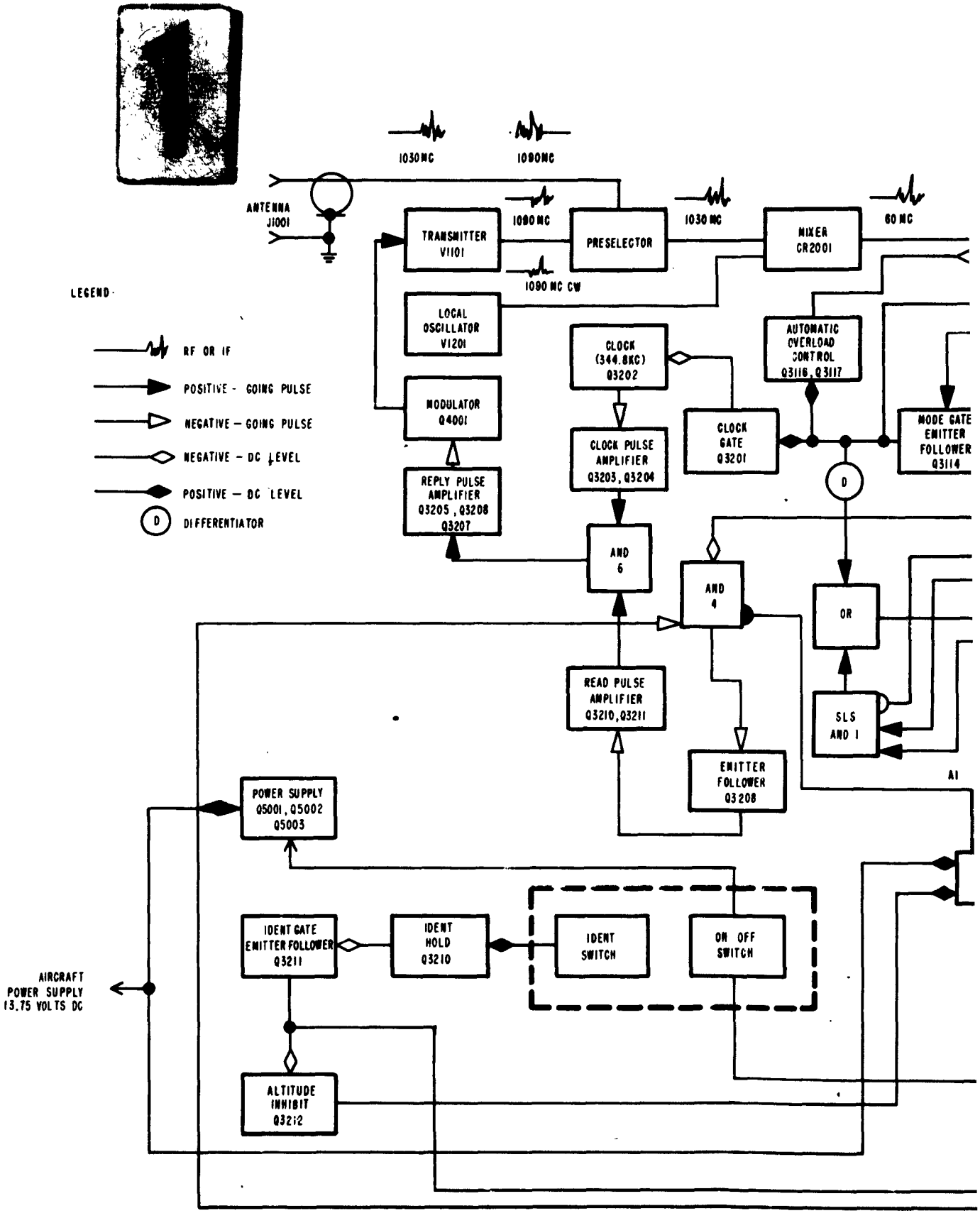

1030 MC
1090 MC
ANTENNA J1001
TRANSMITTER V1101
1090 MC
PRESELECTOR
1030 MC
MIXER CR2001
60 MC
1090 MC CW
LOCAL OSCILLATOR V1201
CLOCK (344.8KC) Q3202
AUTOMATIC OVERLOAD CONTROL Q3116, Q3117
MODULATOR Q4001
CLOCK PULSE AMPLIFIER Q3203, Q3204
CLOCK GATE Q3201
MODE GATE EMITTER FOLLOWER Q3114
REPLY PULSE AMPLIFIER Q3205, Q3206 Q3207
D
AND 6
AND 4
OR
READ PULSE AMPLIFIER Q3210, Q3211
SLS AND 1
EMITTER FOLLOWER Q3208
A1
POWER SUPPLY Q5001, Q5002 Q5003
IDENT GATE EMITTER FOLLOWER Q3211
IDENT HOLD Q3210
IDENT SWITCH
ON OFF SWITCH
AIRCRAFT POWER SUPPLY 13.75 VOLTS DC
ALTITUDE INHIBIT Q3212
LEGEND
RF OR IF
POSITIVE - GOING PULSE
NEGATIVE - GOING PULSE
NEGATIVE - DC LEVEL
POSITIVE - DC LEVEL
D DIFFERENTIATOR

Figure 1.

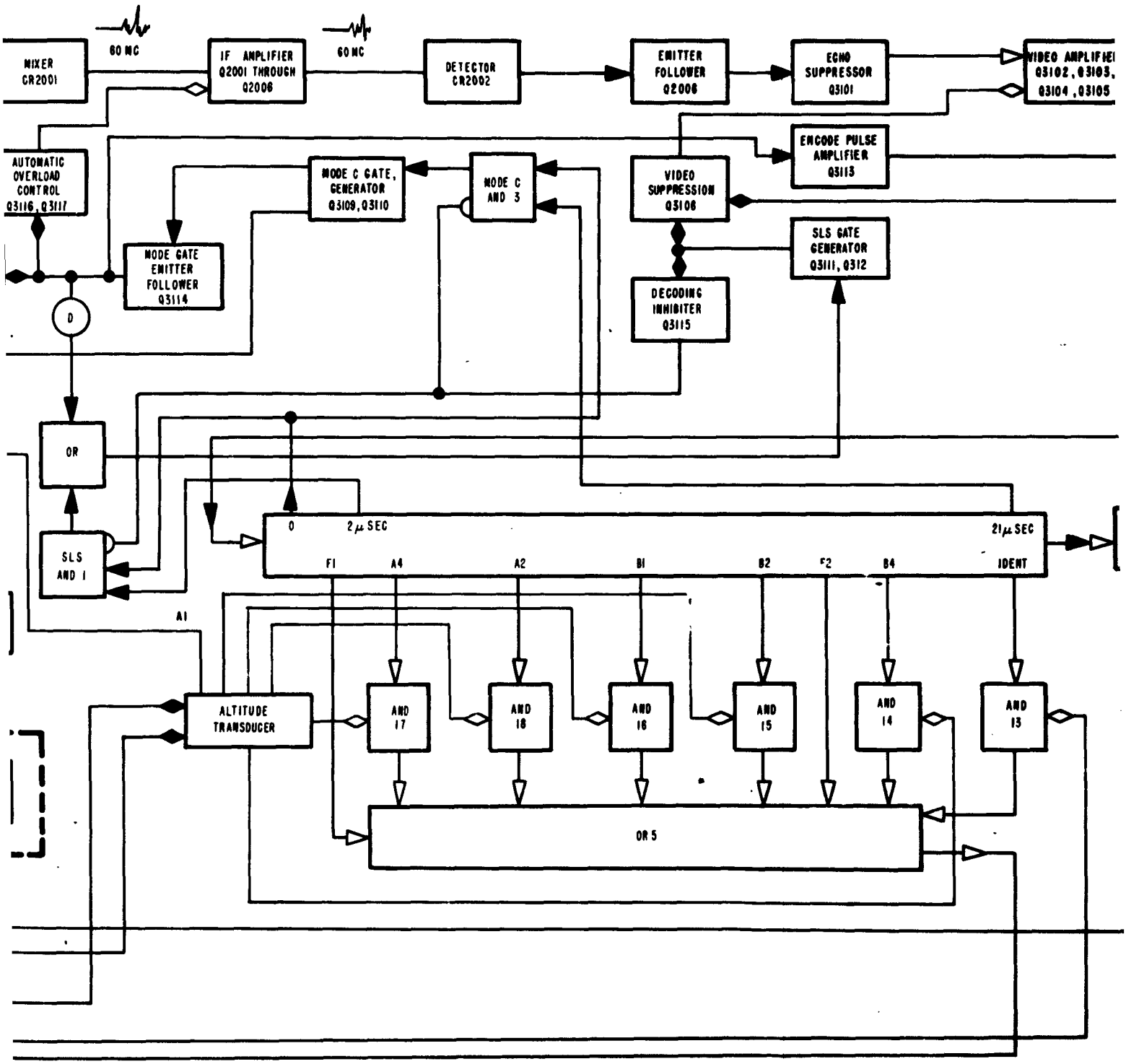
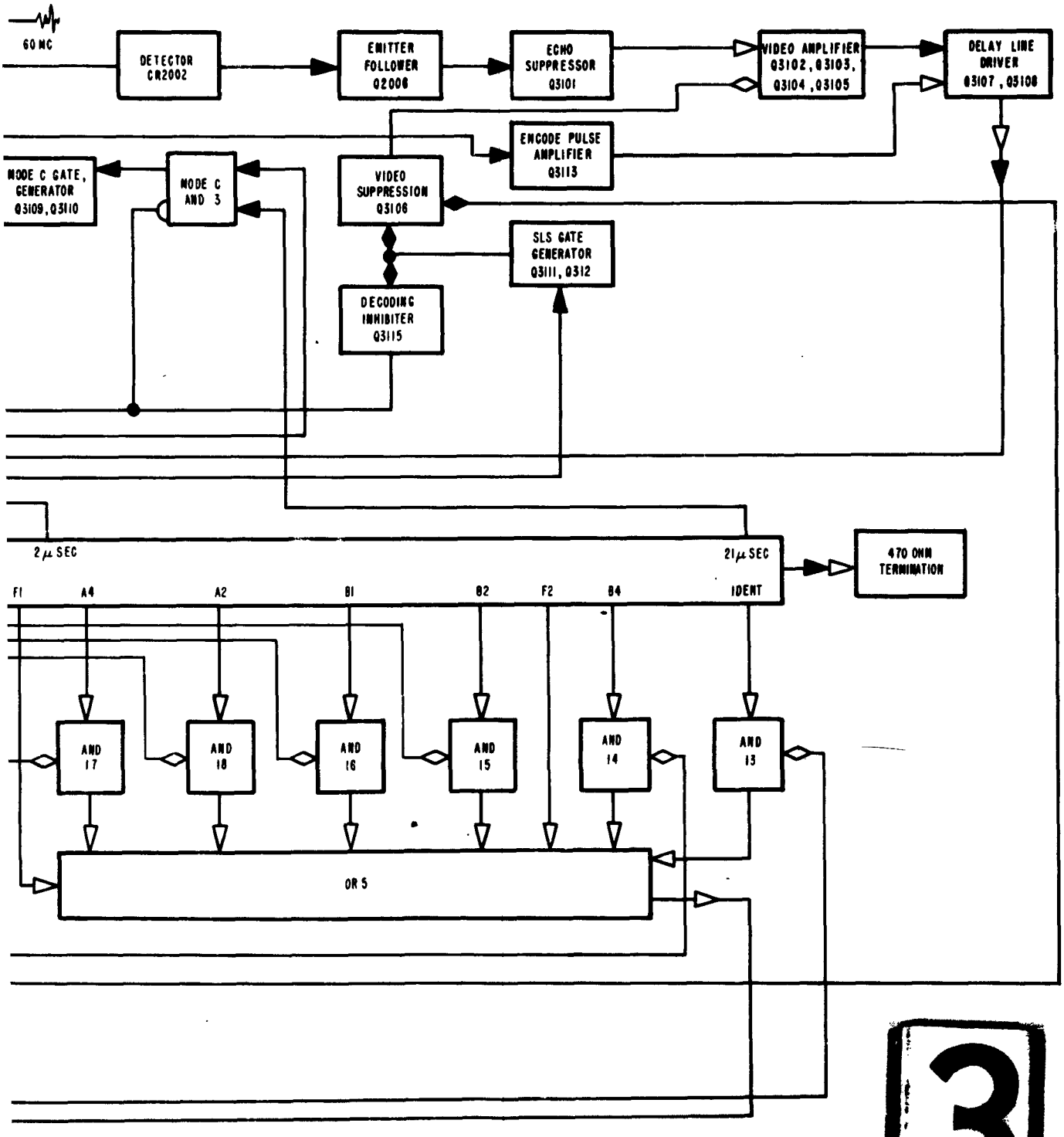


Figure 1. SLATE I Block Diagram



Block Diagram

3

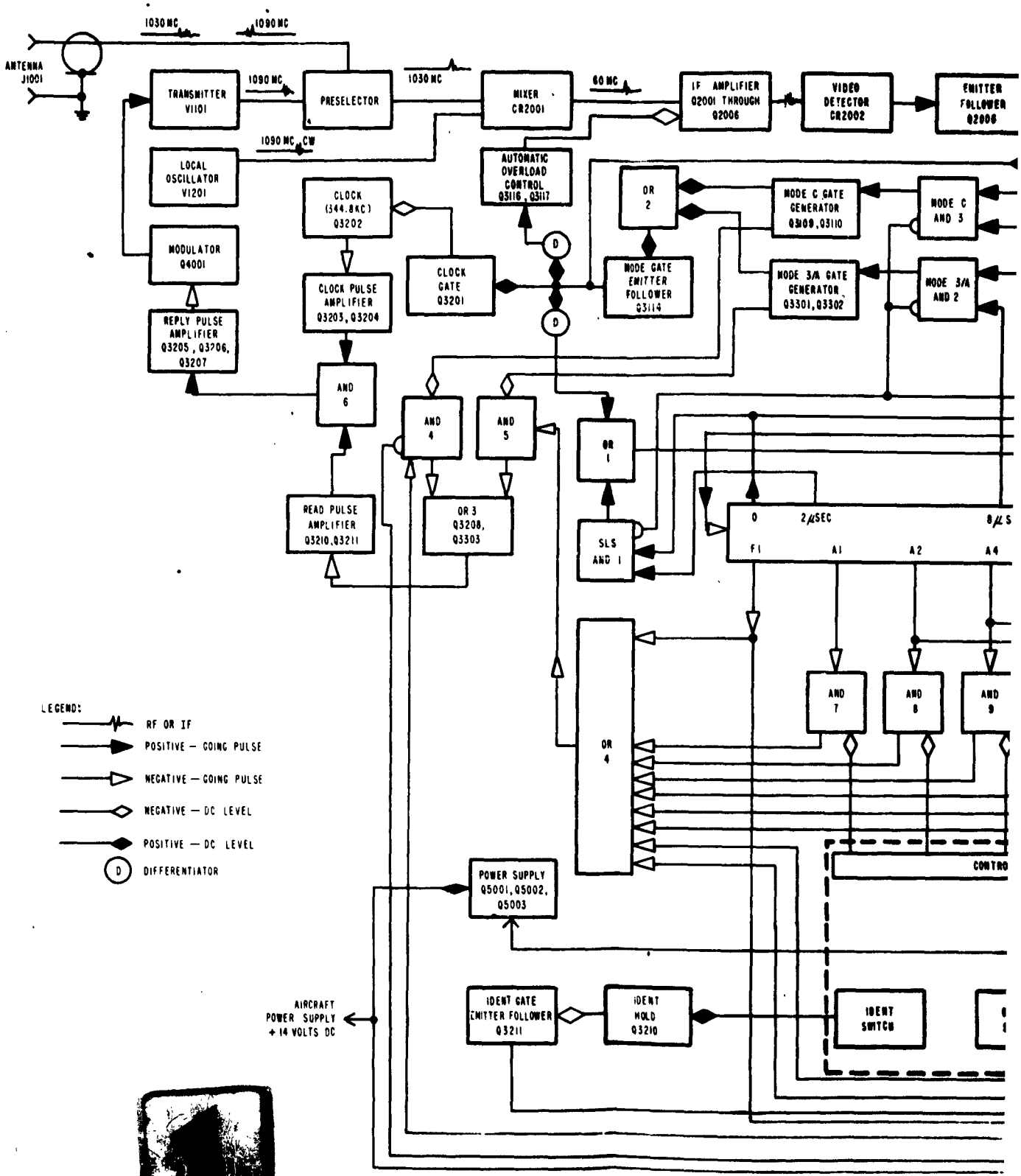


Figure 2. SLATE II Block Diagran

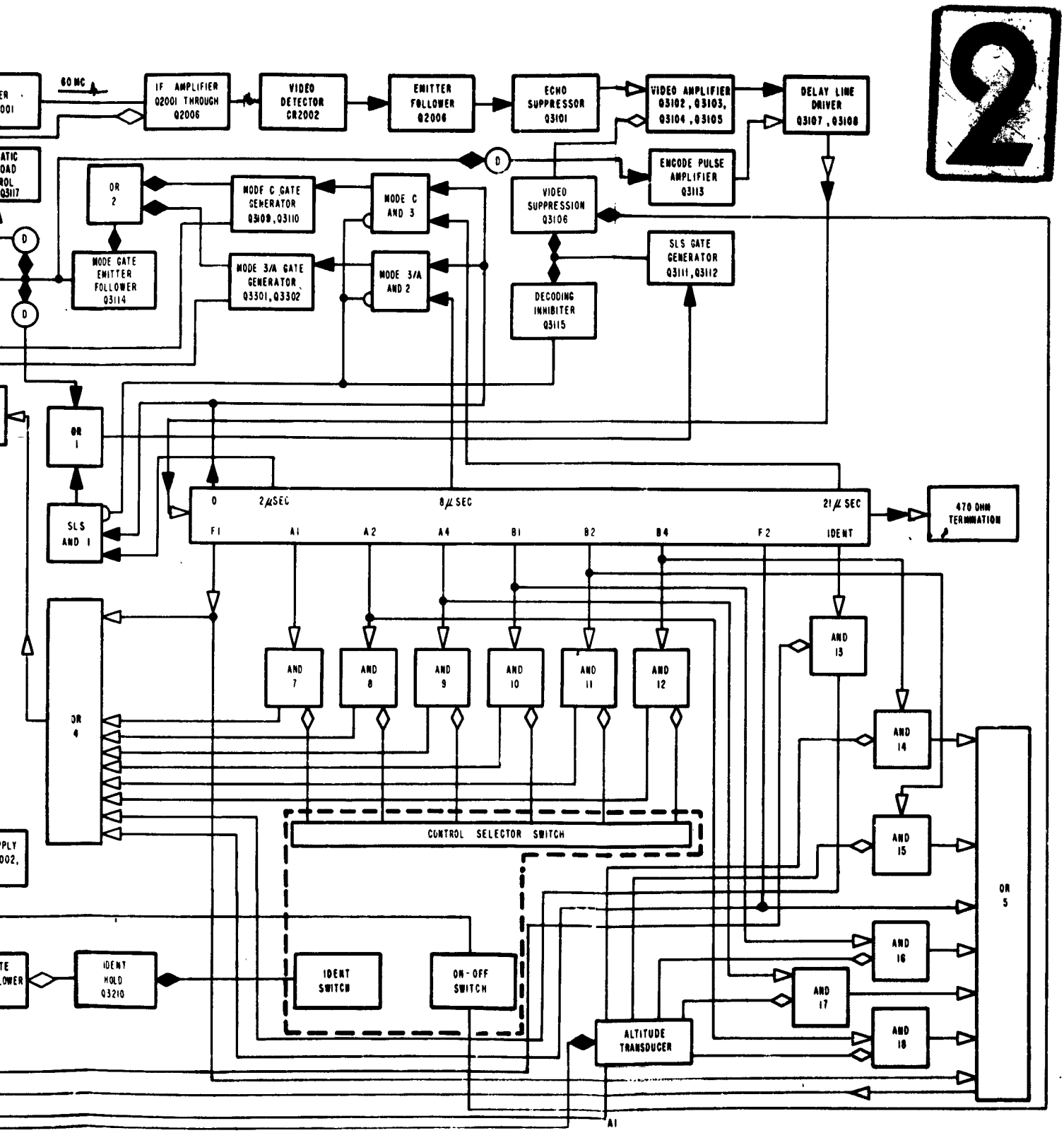
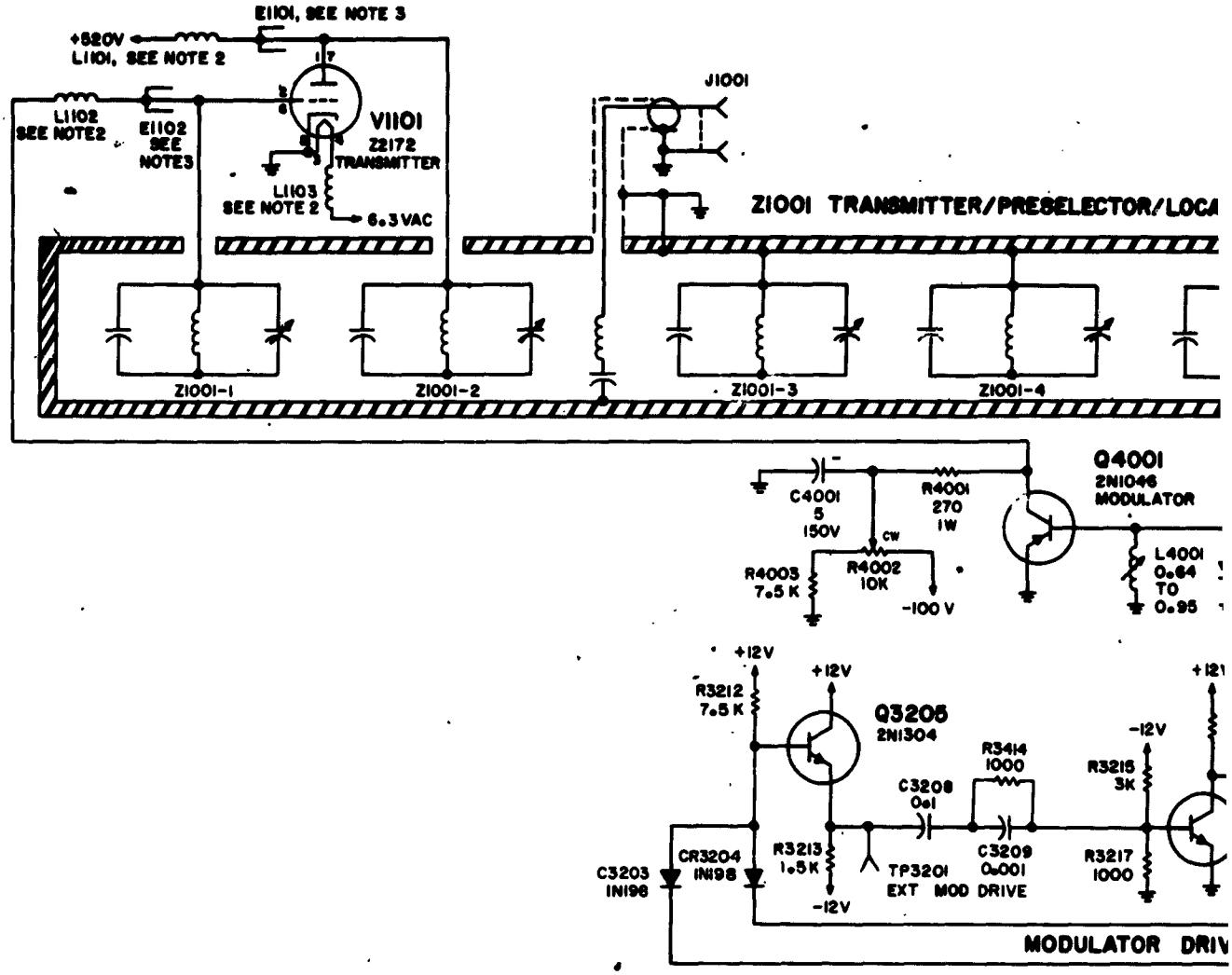
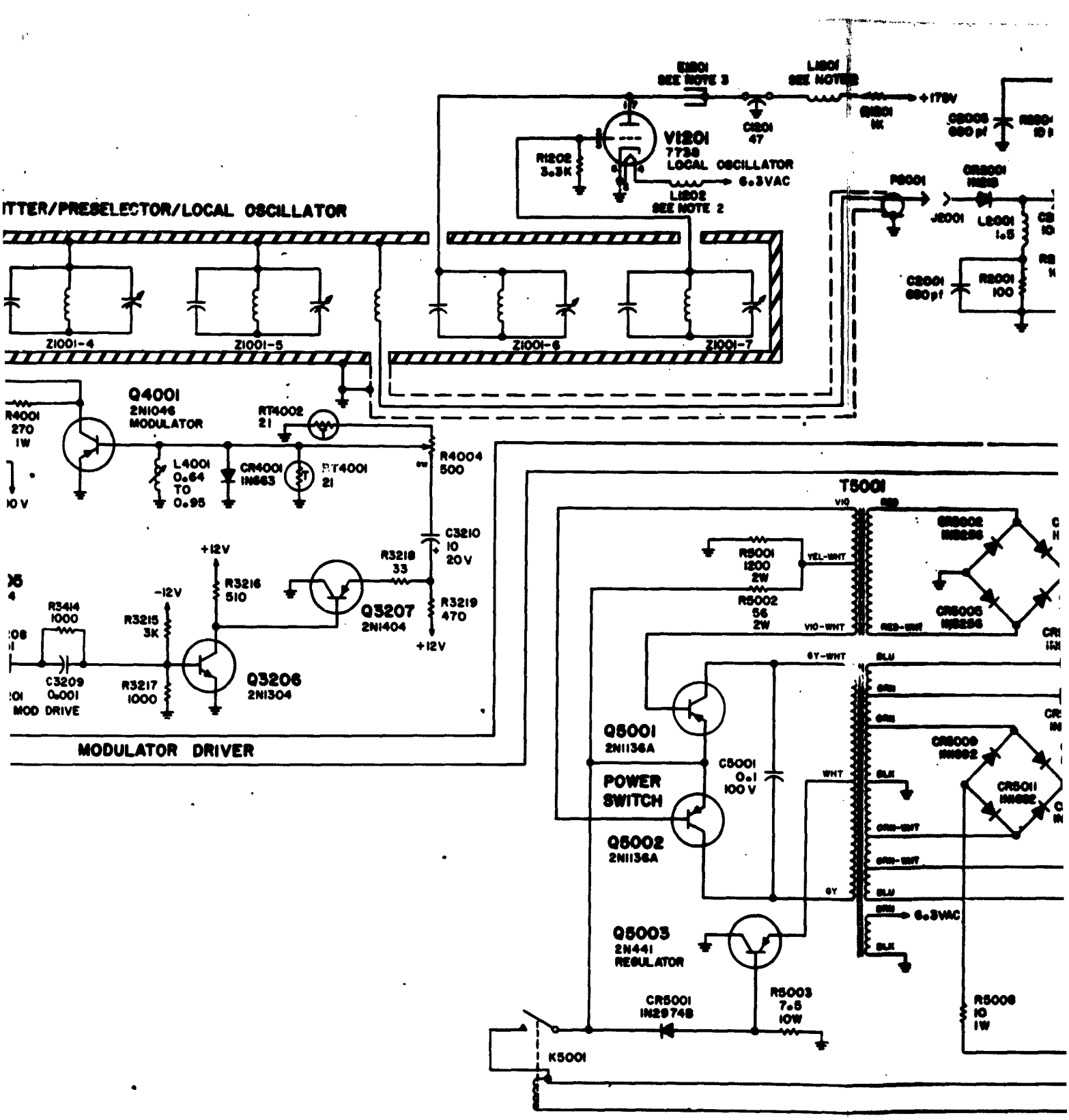
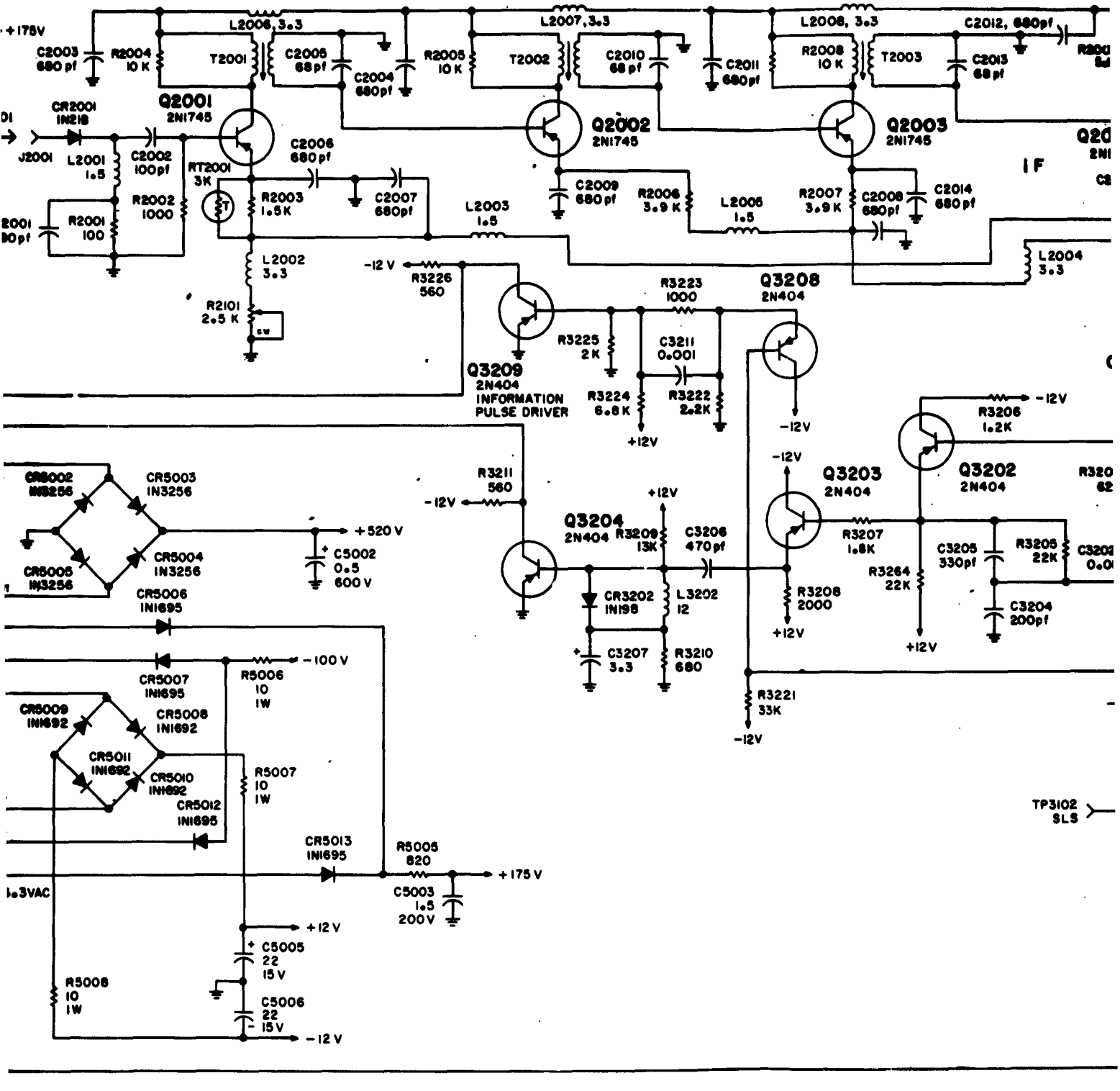


Figure 2. SLATE II Block Diagram


E1101, SEE NOTE 3
+520V
L1101, SEE NOTE 2
L1102
SEE NOTE2
E1102
SEE
NOTE3
V1101
Z2172
TRANSMITTER
L1103
SEE NOTE 2
6.3 VAC
J1001
Z1001 TRANSMITTER/PRESELECTOR/LOCA
Z1001-1
Z1001-2
Z1001-3
Z1001-4
Q4001
2N1046
MODULATOR
C4001
5
150V
R4001
270
1W
CW
R4003
7.5 K
R4002
10K
-100 V
L4001
0.64
TO
0.95
+12V
R3212
7.5 K
Q3205
2N1304
C3208
0.1
R3414
1000
R3215
3K
-12V
C3203
IN198
CR3204
IN198
R3213
1.5K
TP3201
EXT MOD DRIVE
C3209
0.001
R3217
1000
MODULATOR DRIV


ITTER/PRESELECTOR/LOCAL OSCILLATOR
Z1001-4
Z1001-5
Z1001-6
Z1001-7
V1201
7738
LOCAL OSCILLATOR
6.3VAC
R1202
3.3K
C1201
47
+170V
J2001
L2001
1.5
C2001
680 pf
R2001
100
Q4001
2N1046
MODULATOR
RT4002
21
L4001
0.64
TO
0.95
CR4001
IN663
RT4001
21
R4004
500
C3210
10
20V
R3218
33
R3219
470
+12V
R3216
510
-12V
R3215
3K
Q3207
2N1404
R3414
1000
C3209
0.001
R3217
1000
Q3206
2N1304
MOD DRIVE
MODULATOR DRIVER
T5001
R5001
1200
2W
R5002
56
2W
YEL-WHT
VIO-WHT
BLU
GRN
WHT
BLK
6.3VAC
Q5001
2N1136A
POWER
SWITCH
C5001
0.1
100 V
Q5002
2N1136A
Q5003
2N441
REGULATOR
CR5001
IN2974B
R5003
7.5
10W
R5006
10
1W
K5001


+175V
C2003 680 pf
R2004 10 K
L2006, 3.3
T2001
C2005 68 pf
C2004 680pf
R2005 10 K
L2007, 3.3
T2002
C2010 68 pf
C2011 680pf
L2008, 3.3
R2008 10 K
T2003
C2013 68 pf
C2012, 680pf
CR2001 IN218
J2001
L2001 1.5
C2002 100pf
Q2001 2N1745
Q2002 2N1745
Q2003 2N1745
C2006 680 pf
RT2001 3K
R2001 100
R2002 1000
R2003 1.5K
C2007 680pf
C2009 680 pf
R2006 3.9 K
L2006 1.5
R2007 3.9 K
C2008 680pf
C2014 680 pf
L2003 1.5
L2004 3.3
L2002 3.3
R2101 2.5 K
-12 V
R3226 560
Q3208 2N404
R3223 1000
R3225 2K
C3211 0.001
Q3209 2N404 INFORMATION PULSE DRIVER
R3224 6.8K
R3222 2.2K
+12V
-12V
R3206 1.2K
Q3203 2N404
Q3202 2N404
R3211 560
Q3204 2N404
R3209 13K
C3206 470pf
CR3202 IN198
L3202 12
C3207 3.3
R3210 680
R3207 1.8K
R3264 22K
C3205 330pf
R3205 22K
C3204 200pf
R3208 2000
R3221 33K
CR5002 IN3256
CR5003 IN3256
CR5004 IN3256
CR5005 IN3256
+520 V
C5002 0.5 600 V
CR5006 IN1695
CR5007 IN1695
-100 V
R5006 10 1W
CR5009 IN1692
CR5008 IN1692
CR5011 IN1692
CR5010 IN1692
CR5012 IN1695
R5007 10 1W
CR5013 IN1695
R5005 820
+175 V
C5003 1.5 200V
+12 V
C5005 22 15V
C5006 22 15V
-12 V
R5008 10 1W
TP3102 SLS

3

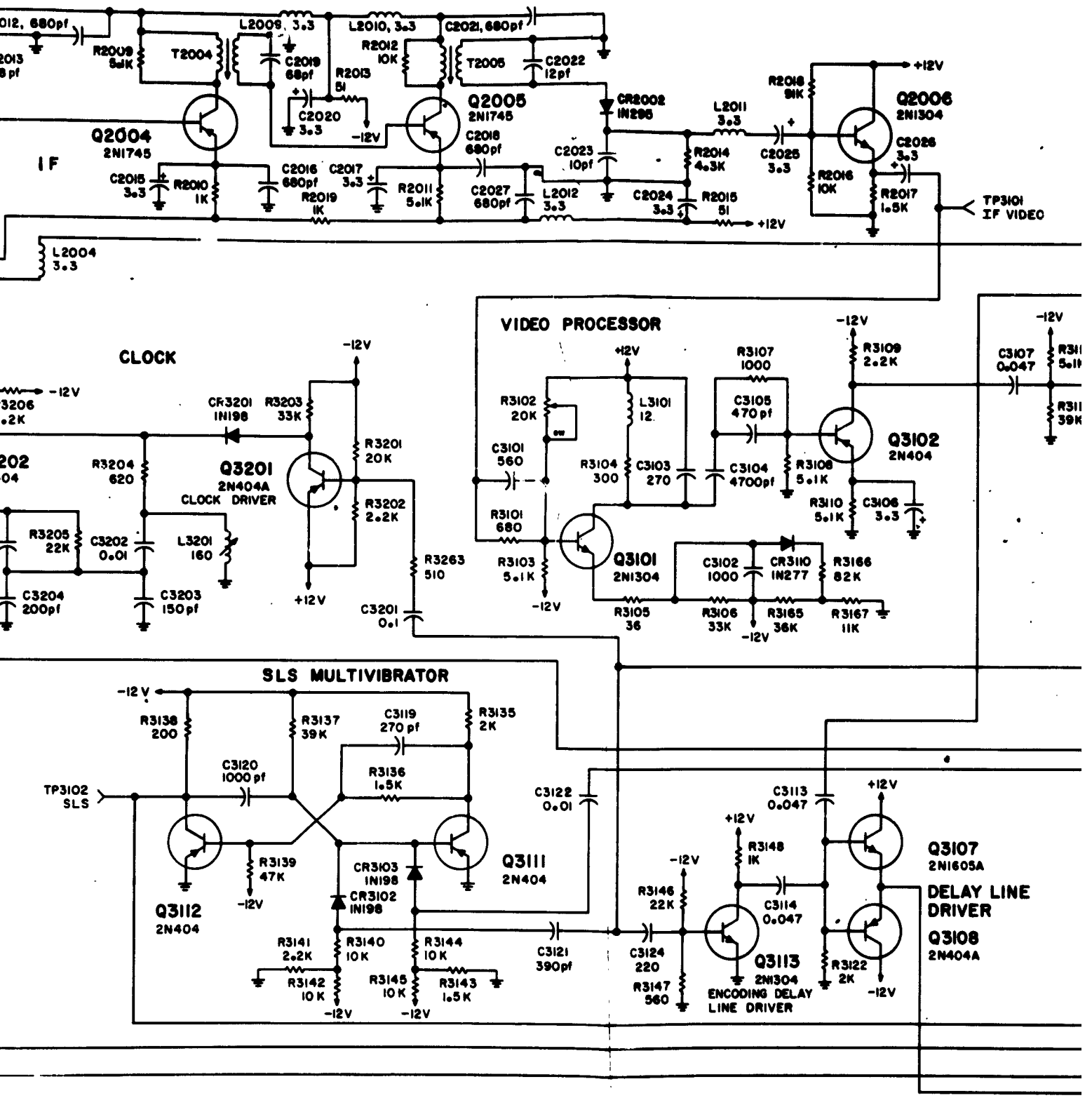
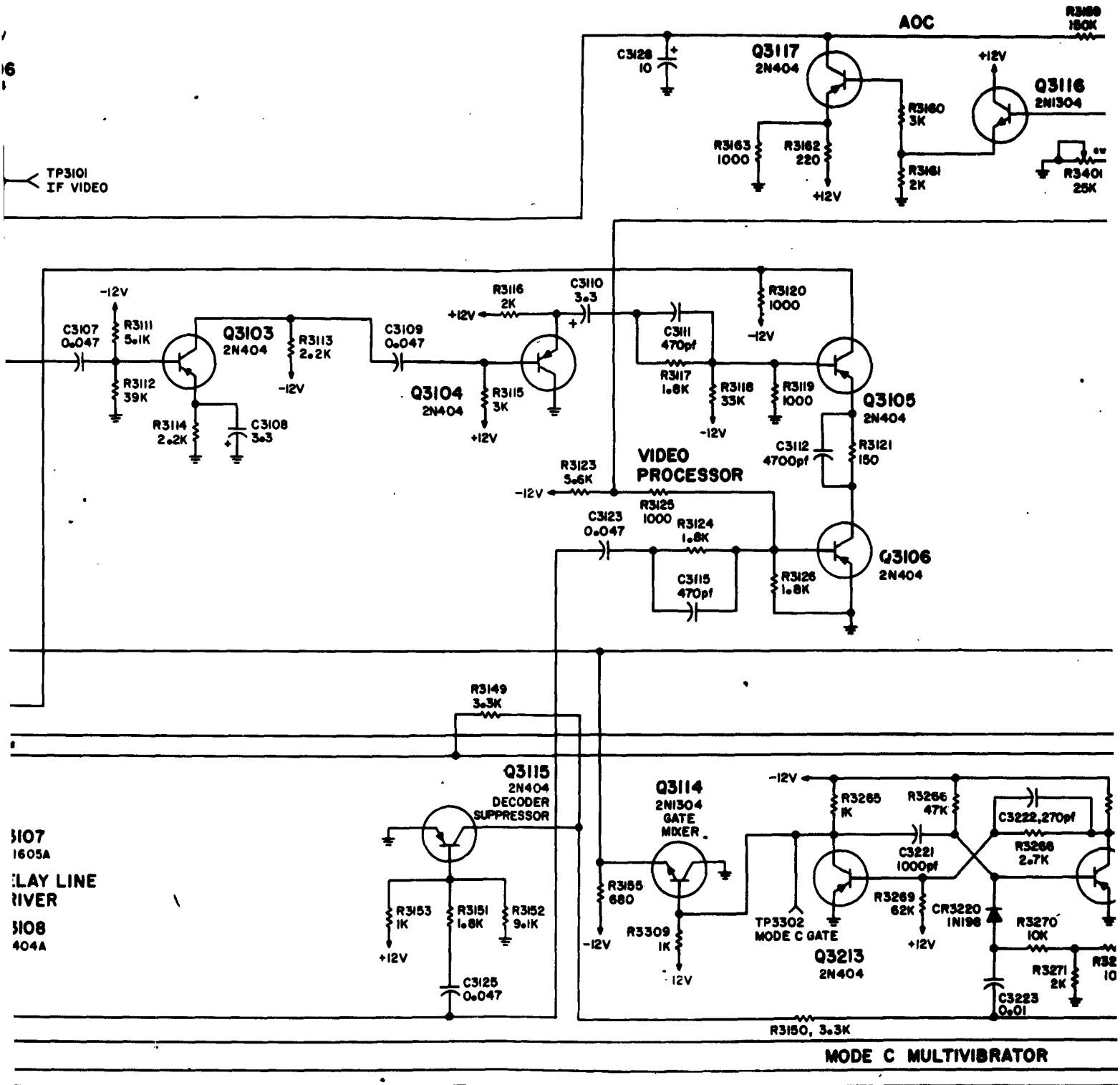
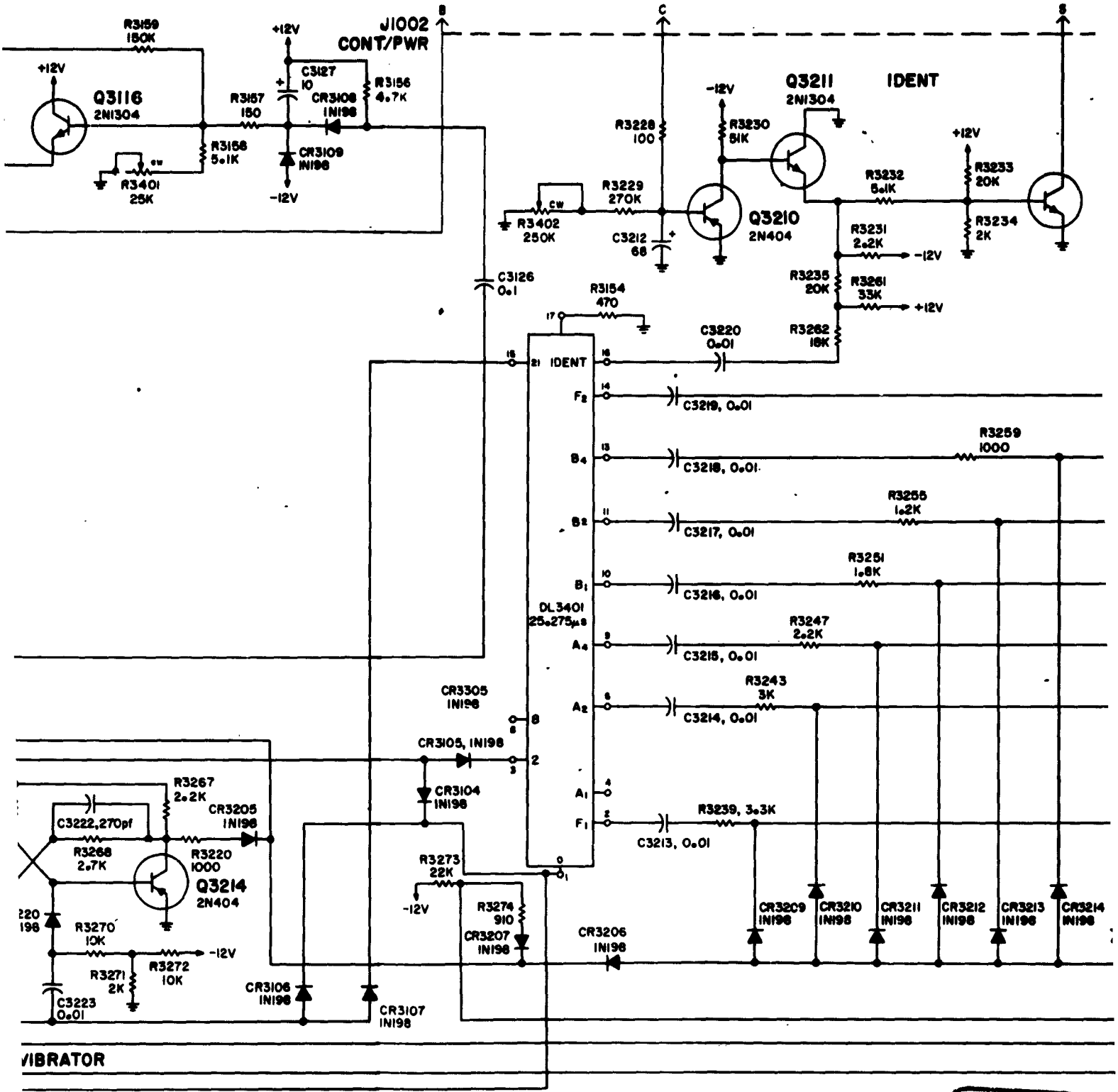


Figure 3. SLATE I Schematic Diagram

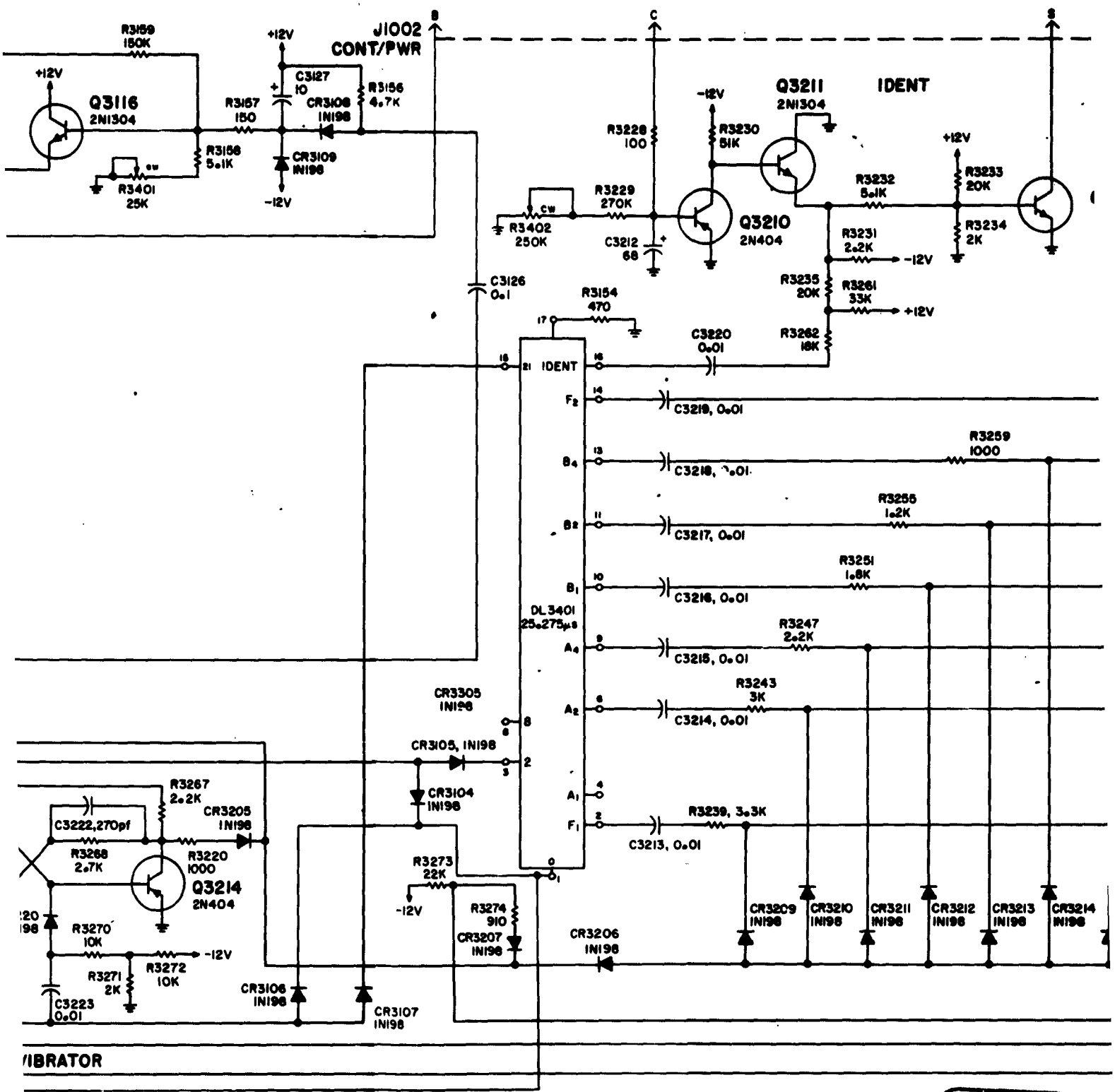
4


AOC
R3159
150K
C3128
10
Q3117
2N404
+12V
Q3116
2N1304
R3160
3K
R3163
1000
R3162
220
R3161
2K
R3401
25K
TP3101
IF VIDEO
-12V
C3107
0.047
R3111
5.1K
Q3103
2N404
R3113
2.2K
R3112
39K
R3114
2.2K
C3108
3.3
C3109
0.047
Q3104
2N404
R3116
2K
C3110
3.3
R3115
3K
C3111
470pf
R3117
1.8K
R3118
33K
R3119
1000
R3120
1000
Q3105
2N404
C3112
4700pf
R3121
150
VIDEO
PROCESSOR
R3123
5.6K
R3125
1000
C3123
0.047
R3124
1.8K
C3115
470pf
R3126
1.8K
Q3106
2N404
R3149
3.3K
Q3115
2N404
DECODER
SUPPRESSOR
R3153
1K
R3151
1.8K
R3152
9.1K
C3125
0.047
Q3114
2N1304
GATE
MIXER
R3155
680
R3309
1K
R3265
1K
R3266
47K
C3222,270pf
C3221
1000pf
R3268
2.7K
R3269
62K
CR3220
1N198
TP3302
MODE C GATE
Q3213
2N404
R3270
10K
R3271
2K
C3223
0.01
R3150, 3.3K
MODE C MULTIVIBRATOR

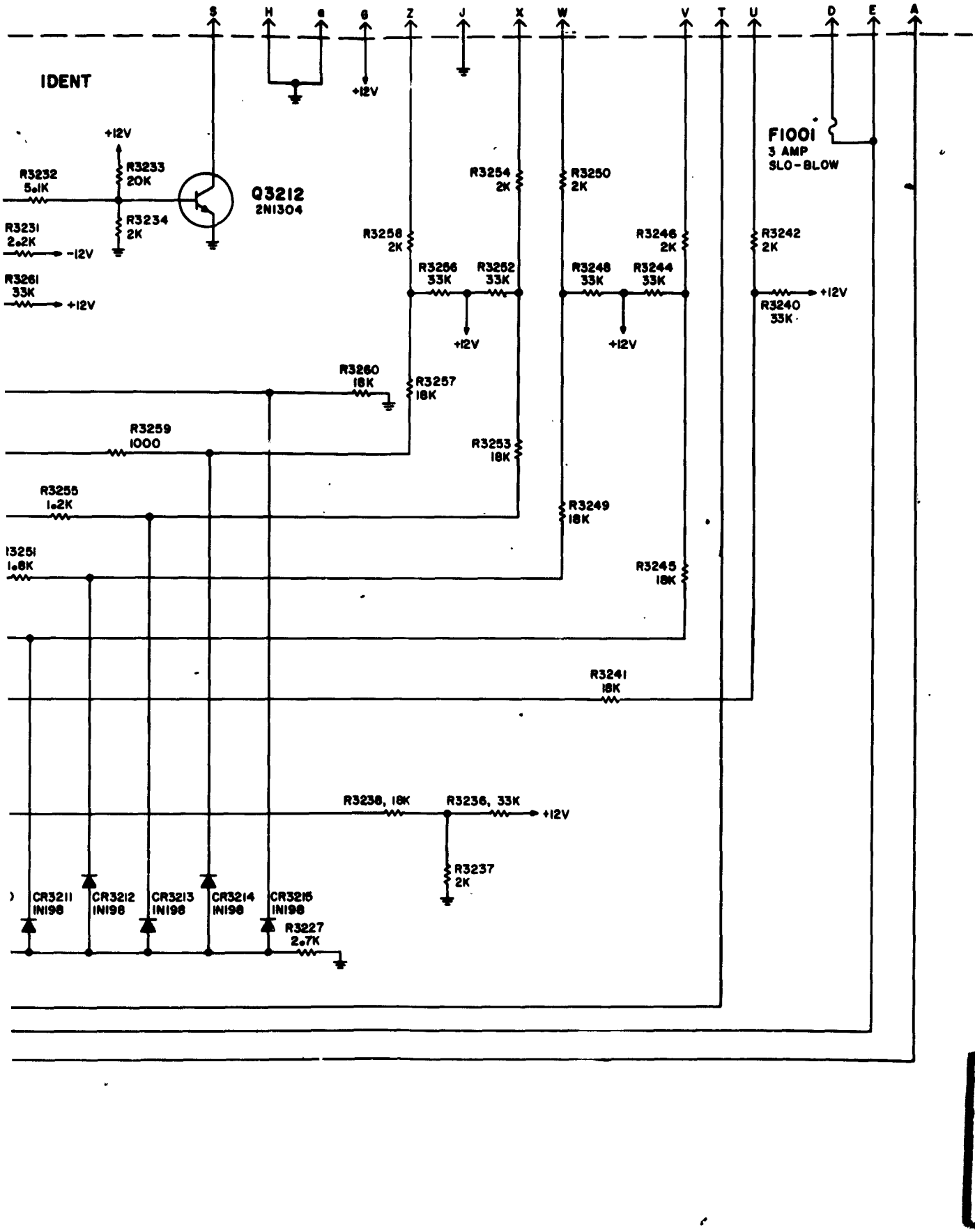
5


J1002
CONT/PWR
Q3116
2N1304
Q3211
IDENT
2N1304
Q3210
2N404
Q3214
2N404
+12V
-12V
R3159
150K
R3156
5.1K
R3401
25K
C3127
10
R3157
150
CR3108
1N198
R3156
4.7K
CR3109
1N198
R3228
100
R3230
51K
R3229
270K
R3402
250K
C3212
68
R3232
5.1K
R3233
20K
R3234
2K
R3231
2.2K
R3235
20K
R3261
33K
R3262
18K
C3126
0.1
R3154
470
C3220
0.01
IDENT
C3219, 0.01
C3218, 0.01
C3217, 0.01
C3216, 0.01
C3215, 0.01
C3214, 0.01
C3213, 0.01
R3259
1000
R3255
1.2K
R3251
1.8K
R3247
2.2K
R3243
3K
R3239, 3.3K
DL3401
25.275μs
CR3305
1N198
CR3105, 1N198
CR3104
1N198
R3267
2.2K
CR3205
1N198
C3222,270pf
R3268
2.7K
R3220
1000
R3273
22K
R3274
910
CR3207
1N198
CR3206
1N198
R3270
10K
R3271
2K
R3272
10K
C3223
0.01
CR3106
1N198
CR3107
1N198
CR3209
1N198
CR3210
1N198
CR3211
1N198
CR3212
1N198
CR3213
1N198
CR3214
1N198
VIBRATOR

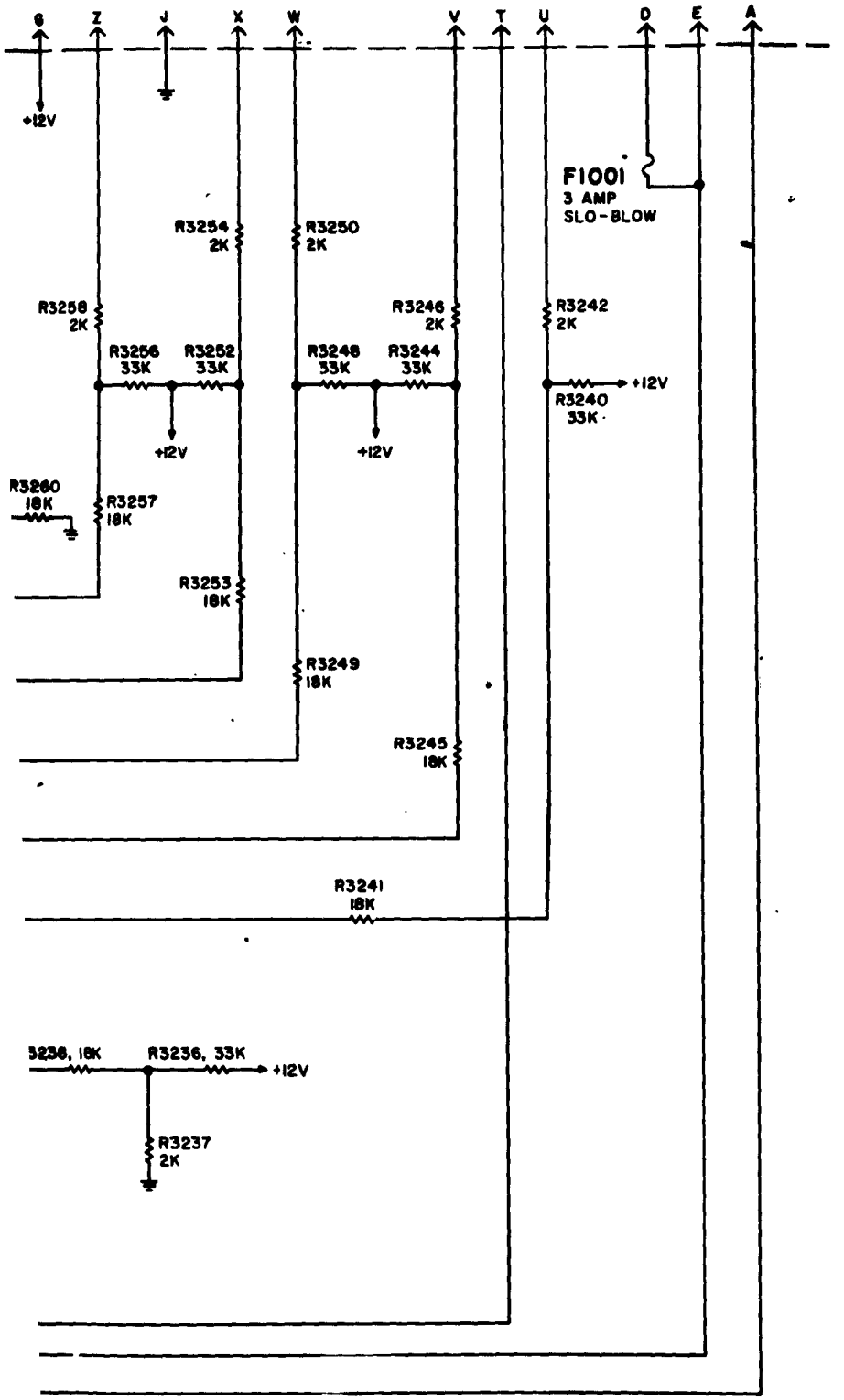
6


J1002
CONT/PWR
Q3116
2N1304
R3159
150K
+12V
R3157
150
C3127
10
CR3108
1N198
R3156
4.7K
R3158
5.1K
R3401
25K
CR3109
1N198
-12V
Q3211
2N1304
IDENT
R3228
100
R3230
51K
R3229
270K
R3402
250K
Q3210
2N404
C3212
68
R3232
5.1K
R3233
20K
R3234
2K
R3231
2.2K
R3235
20K
R3261
33K
R3262
18K
C3126
0.1
R3154
470
C3220
0.01
DL3401
25.275μs
IDENT
F2
B4
B2
B1
A4
A2
A1
F1
C3219, 0.01
C3218, 0.01
C3217, 0.01
C3216, 0.01
C3215, 0.01
C3214, 0.01
C3213, 0.01
R3259
1000
R3255
1.2K
R3251
1.8K
R3247
2.2K
R3243
3K
R3239, 3.3K
CR3305
1N198
CR3105, 1N198
CR3104
1N198
R3267
2.2K
CR3205
1N198
C3222,270pf
R3268
2.7K
R3220
1000
Q3214
2N404
R3270
10K
R3271
2K
R3272
10K
C3223
0.01
R3273
22K
R3274
910
CR3207
1N198
CR3106
1N198
CR3107
1N198
CR3206
1N198
CR3209
1N198
CR3210
1N198
CR3211
1N198
CR3212
1N198
CR3213
1N198
CR3214
1N198
IBRATOR

6


S
H
G
Z
J
X
W
V
T
U
D
E
A
IDENT
+12V
R3232
5.1K
R3233
20K
R3234
2K
Q3212
2N1304
R3231
2.2K
-12V
R3261
33K
+12V
F1001
3 AMP
SLO-BLOW
R3254
2K
R3250
2K
R3258
2K
R3246
2K
R3242
2K
R3256
33K
R3252
33K
R3248
33K
R3244
33K
R3240
33K
R3260
18K
R3257
18K
R3259
1000
R3253
18K
R3255
1.2K
R3249
18K
R3251
1.8K
R3245
18K
R3241
18K
R3238, 18K
R3236, 33K
R3237
2K
CR3211
IN198
CR3212
IN198
CR3213
IN198
CR3214
IN198
CR3215
IN198
R3227
2.7K

7



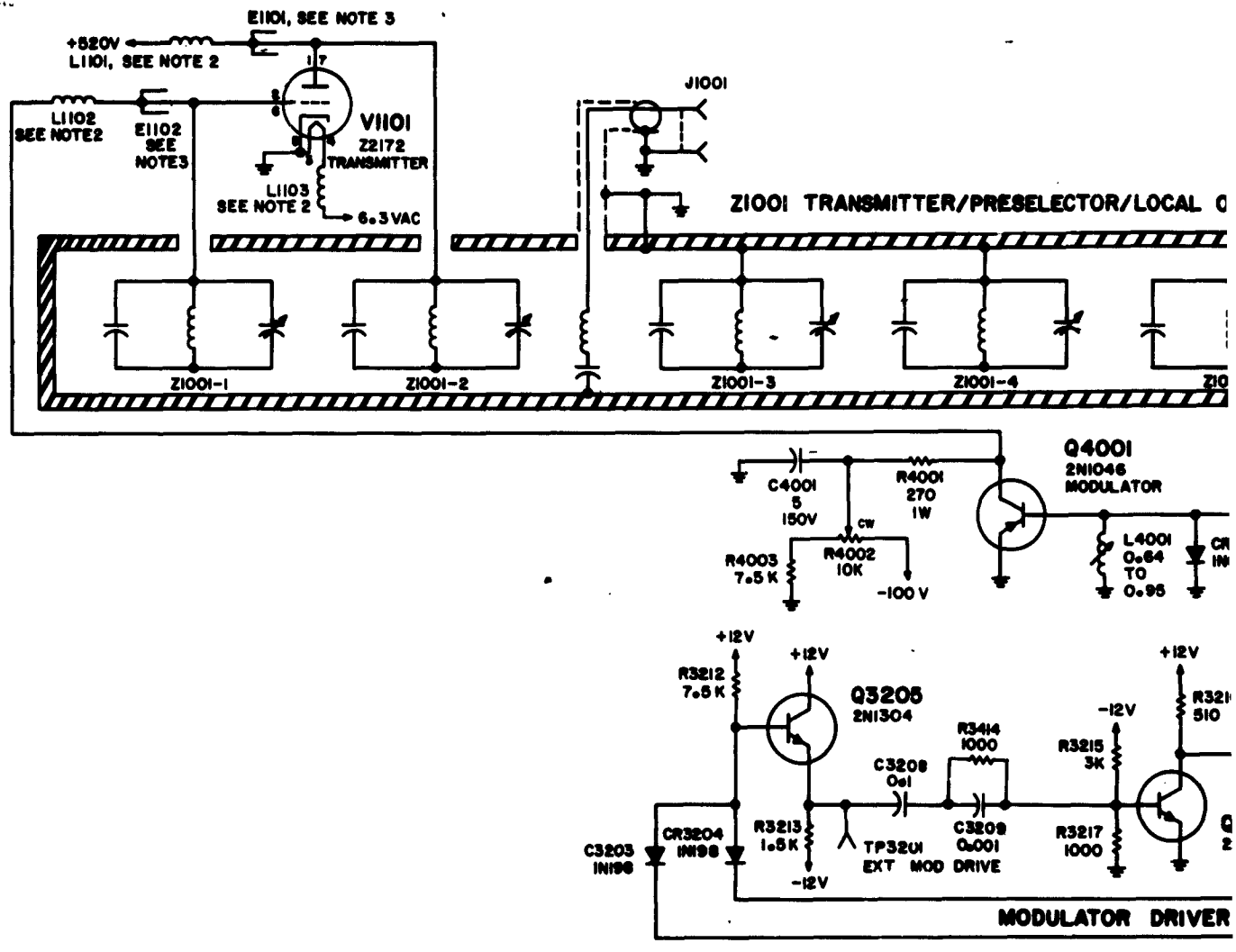
SLATE 1

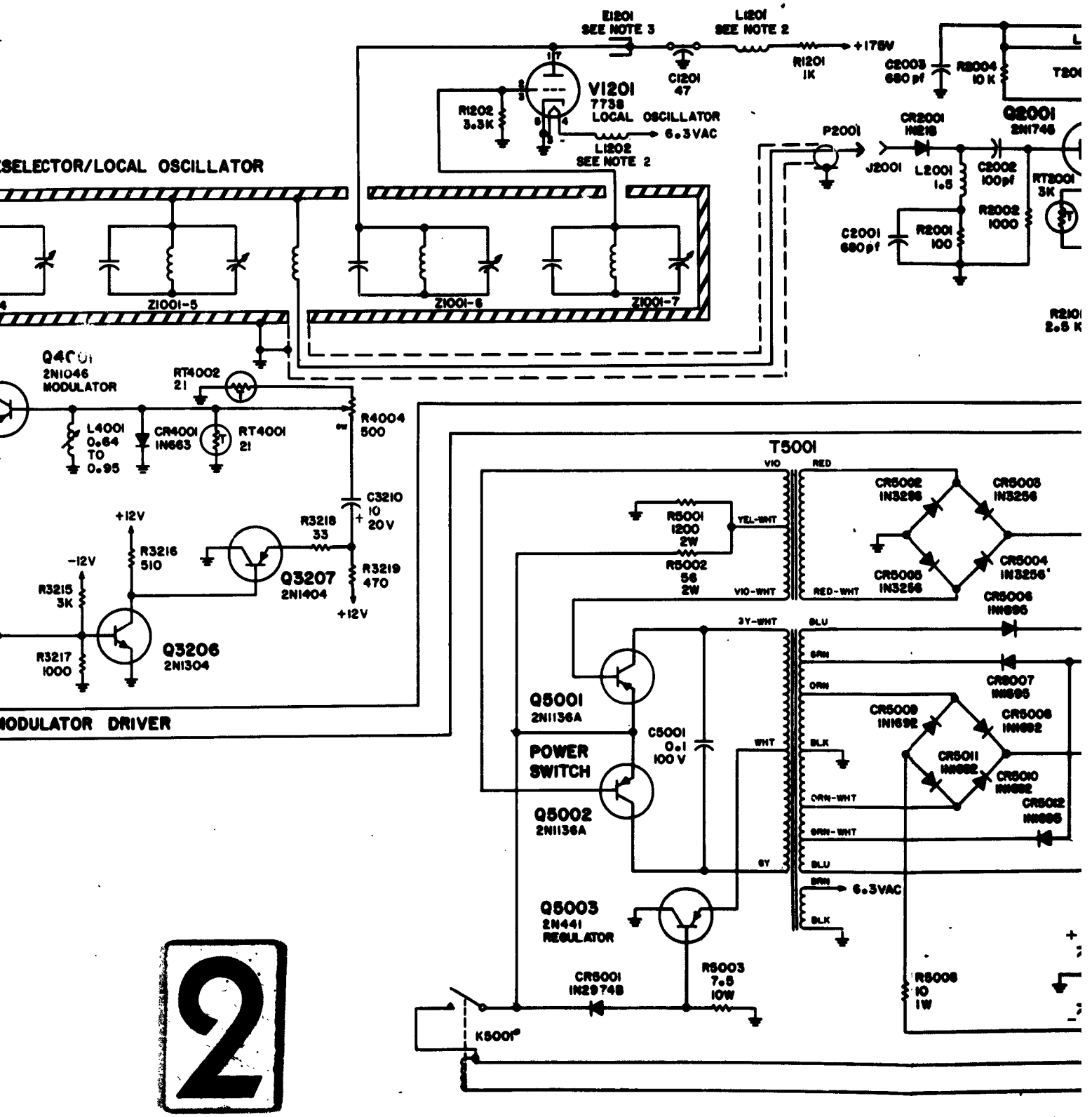
HAZELTINE
SMALL LIGHT-WEIGHT ALTITUDE TRANSMISSION EQUIPMENT

UNLESS OTHERWISE NOTED:

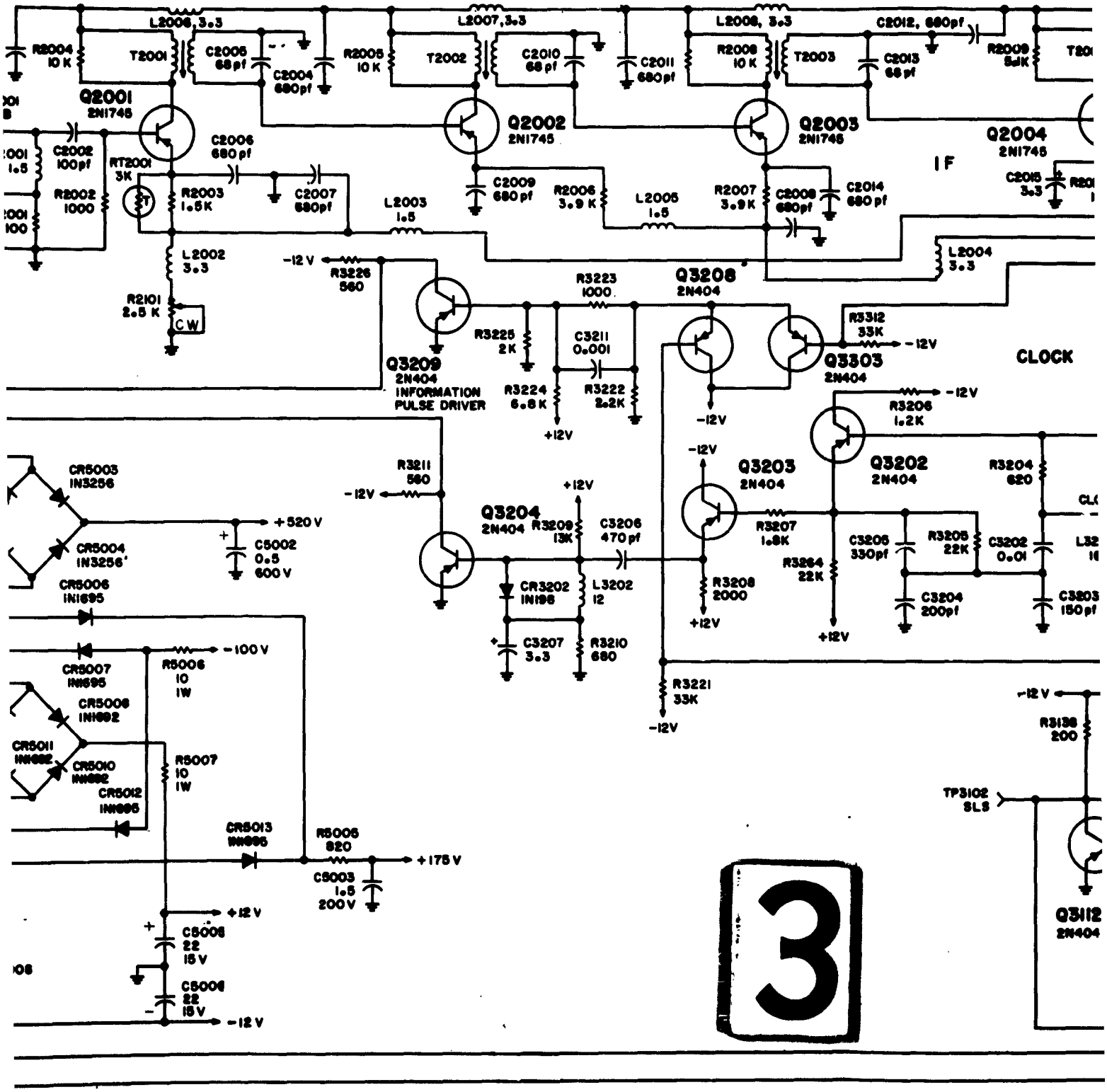
1. RESISTANCES ARE SHOWN IN OHMS, CAPACITANCES ARE SHOWN IN MICROFARADS
2. 9 TURNS NO. 28 WIRE
3. SHORTED QUARTER-WAVELENGTH LINE
4. RELAYS SHOWN IN DE-ENERGIZED CONDITION

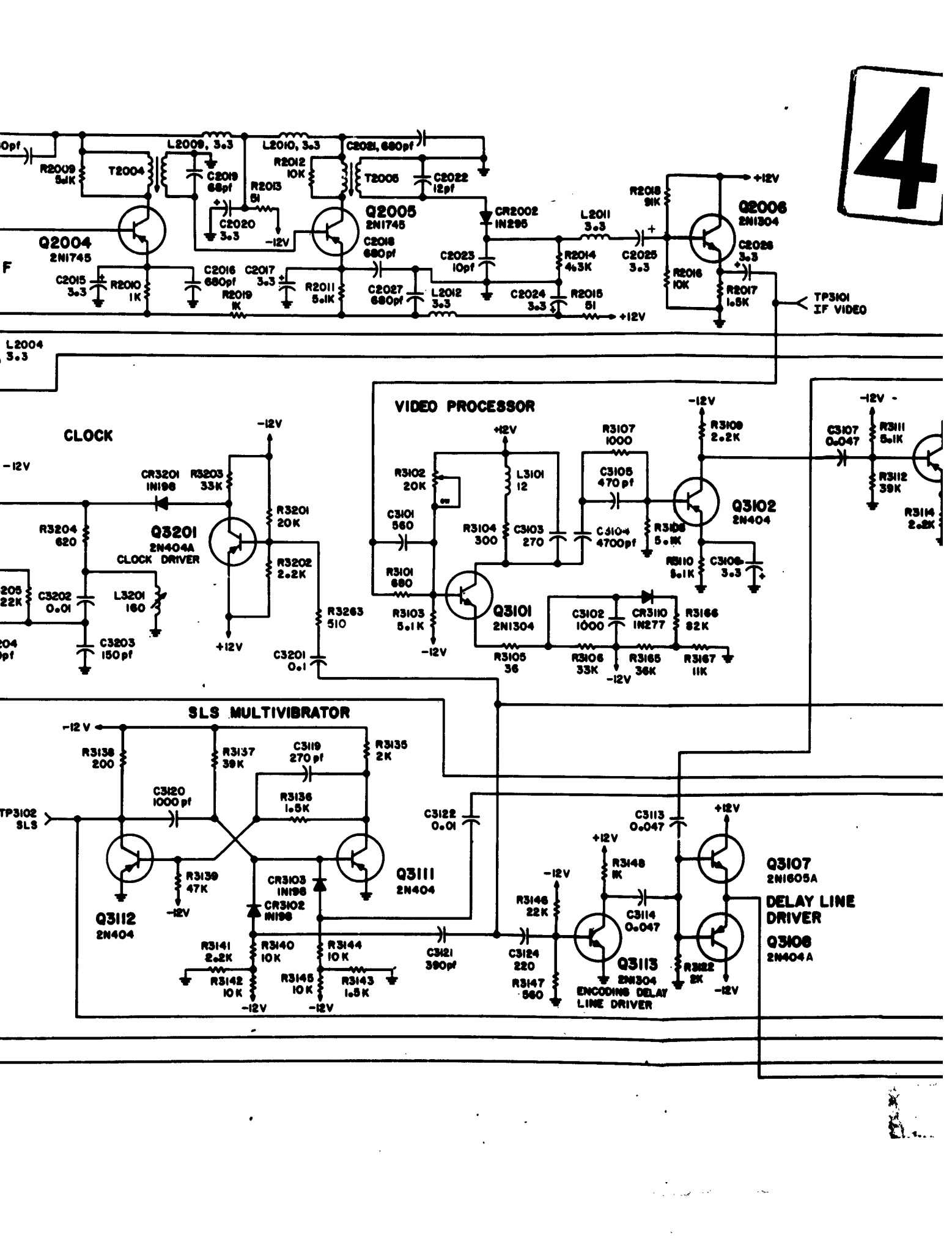
8


E1101, SEE NOTE 3
+520V
L1101, SEE NOTE 2
L1102
SEE NOTE2
E1102
SEE
NOTE3
V1101
Z2172
TRANSMITTER
L1103
SEE NOTE 2
6.3VAC
J1001
Z1001 TRANSMITTER/PRESELECTOR/LOCAL O
Z1001-1
Z1001-2
Z1001-3
Z1001-4
Q4001
2N1046
MODULATOR
C4001
5
150V
R4001
270
1W
CW
R4002
10K
R4003
7.5K
-100 V
L4001
0.64
TO
0.95
+12V
R3212
7.5K
Q3205
2N1304
R3414
1000
C3208
0.01
R3213
1.5K
C3209
0.001
TP3201
EXT MOD DRIVE
R3215
3K
R3217
1000
-12V
CR3204
IN198
C3203
IN198
MODULATOR DRIVER


E1201
SEE NOTE 3
L1201
SEE NOTE 2
+175V
R1201
1K
C1201
47
V1201
7738
LOCAL OSCILLATOR
R1202
3.3K
6.3VAC
L1202
SEE NOTE 2
C2003
680 pf
R2004
10 K
Q2001
2N1746
CR2001
IN218
P2001
J2001
L2001
1.5
C2002
100pf
RT2001
3K
R2002
1000
C2001
680pf
R2001
100
SELECTOR/LOCAL OSCILLATOR
Z1001-5
Z1001-6
Z1001-7
Q4001
2N1046
MODULATOR
RT4002
21
L4001
0.64
TO
0.95
CR4001
IN663
RT4001
21
R4004
500
C3210
10
20V
+12V
R3218
33
R3216
510
-12V
Q3207
2N1404
R3219
470
+12V
R3215
3K
Q3206
2N1304
R3217
1000
MODULATOR DRIVER
T5001
VIO
RED
R5001
1200
2W
YEL-WHT
R5002
56
2W
VIO-WHT
RED-WHT
CR5002
IN3256
CR5003
IN3256
CR5005
IN3256
CR5004
IN3256
CR5006
IN695
3Y-WHT
BLU
GRN
ORN
CR5007
IN695
CR5009
IN692
CR5008
IN692
CR5011
IN692
CR5010
IN692
CR5012
IN695
Q5001
2N1136A
POWER
SWITCH
C5001
0.1
100 V
WHT
BLK
Q5002
2N1136A
ORN-WHT
GRN-WHT
BLU
6Y
BRN
6.3VAC
BLK
Q5003
2N441
REGULATOR
CR5001
IN2974B
R5003
7.5
10W
R5006
10
1W
K5001

2


L2006, 3.3
L2007, 3.3
L2008, 3.3
C2012, 680pf
R2004 10 K
T2001
C2005 68 pf
C2004 680pf
R2005 10 K
T2002
C2010 68 pf
C2011 680pf
R2008 10 K
T2003
C2013 68 pf
R2009 5.1K
Q2001 2N1745
Q2002 2N1745
Q2003 2N1745
Q2004 2N1745
IF
C2002 100pf
R2002 1000
RT2001 3K
R2003 1.5K
C2006 680 pf
C2007 680pf
C2009 680 pf
R2006 3.9 K
L2005 1.5
R2007 3.9K
C2008 680pf
C2014 680 pf
C2015 3.3
L2003 1.5
L2004 3.3
L2002 3.3
R2101 2.5 K
CW
-12 V
R3226 560
Q3208 2N404
R3223 1000
R3225 2K
C3211 0.001
Q3209 2N404 INFORMATION PULSE DRIVER
R3224 6.8K
R3222 2.2K
+12V
R3312 33K
-12V
Q3303 2N404
CLOCK
R3206 1.2K
Q3203 2N404
Q3202 2N404
R3204 620
R3207 1.8K
C3205 330pf
R3205 22K
C3202 0.01
R3264 22K
C3204 200pf
C3203 150pf
CR5003 IN3256
CR5004 IN3256
+520 V
C5002 0.5 600 V
R3211 560
Q3204 2N404
R3209 13K
C3206 470 pf
R3208 2000
CR3202 IN198
L3202 12
C3207 3.3
R3210 680
CR5006 IN1695
CR5007 IN1695
R5006 10 1W
-100 V
CR5008 IN1692
CR5011 IN1692
CR5010 IN1692
CR5012 IN1695
R5007 10 1W
CR5013 IN1695
R5005 820
+175 V
C5003 1.5 200 V
+12 V
C5005 22 15 V
C5006 22 15 V
-12 V
R3221 33K
R3138 200
TP3102 SLS
Q3112 2N404
3


4
L2009, 3.3
L2010, 3.3
C2021, 680pf
R2009 5.1K
T2004
C2019 68pf
R2012 10K
T2005
C2022 12pf
R2013 51
C2020 3.3
-12V
Q2004 2N1745
Q2005 2N1745
CR2002 IN295
L2011 3.3
R2018 9K
+12V
Q2006 2N1304
C2015 3.3
R2010 1K
C2016 680pf
R2019 1K
C2017 3.3
R2011 5.1K
C2018 680pf
C2023 10pf
R2014 4.3K
C2025 3.3
C2026 3.3
R2016 10K
R2017 1.5K
TP3101 IF VIDEO
C2027 680pf
L2012 3.3
C2024 3.3
R2015 51
+12V
L2004 3.3
CLOCK
-12V
CR3201 IN198
R3203 33K
R3201 20K
R3204 620
Q3201 2N404A CLOCK DRIVER
C3202 0.01
L3201 160
C3203 150pf
R3202 2.2K
+12V
R3263 510
C3201 0.1
VIDEO PROCESSOR
+12V
R3102 20K
R3107 1000
L3101 12
C3105 470pf
R3109 2.2K
-12V
C3101 560
R3104 300
C3103 270
C3104 4700pf
R3108 5.1K
Q3102 2N404
R3110 5.1K
C3106 3.3
R3101 680
R3103 5.1K
Q3101 2N1304
C3102 1000
CR3110 IN277
R3166 82K
R3105 36
R3106 33K
R3165 36K
R3167 11K
-12V
C3107 0.047
R3111 5.1K
R3112 39K
R3114 2.2K
SLS MULTIVIBRATOR
-12 V
R3138 200
R3137 39K
C3119 270 pf
R3135 2K
C3120 1000 pf
R3136 1.5K
TP3102 SLS
C3122 0.01
Q3111 2N404
R3139 47K
Q3112 2N404
CR3103 IN198
CR3102 IN198
R3141 2.2K
R3140 10K
R3144 10K
R3142 10K
R3145 10K
R3143 1.5K
C3121 390pf
C3124 220
R3147 560
C3113 0.047
+12V
R3148 1K
C3114 0.047
Q3113 2N1304 ENCODING DELAY LINE DRIVER
R3122 2K
Q3107 2N1605A DELAY LINE DRIVER
Q3108 2N404A

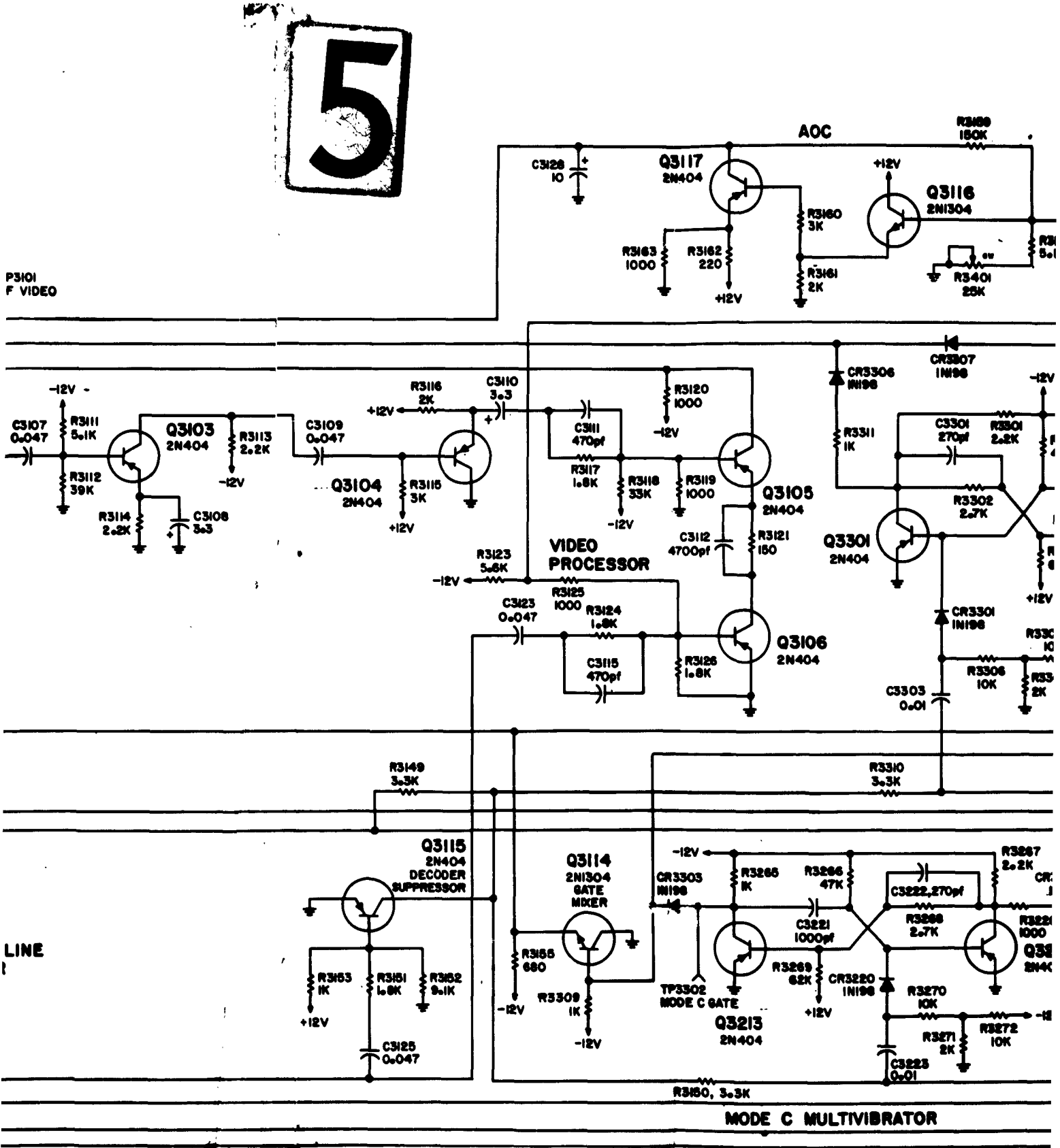
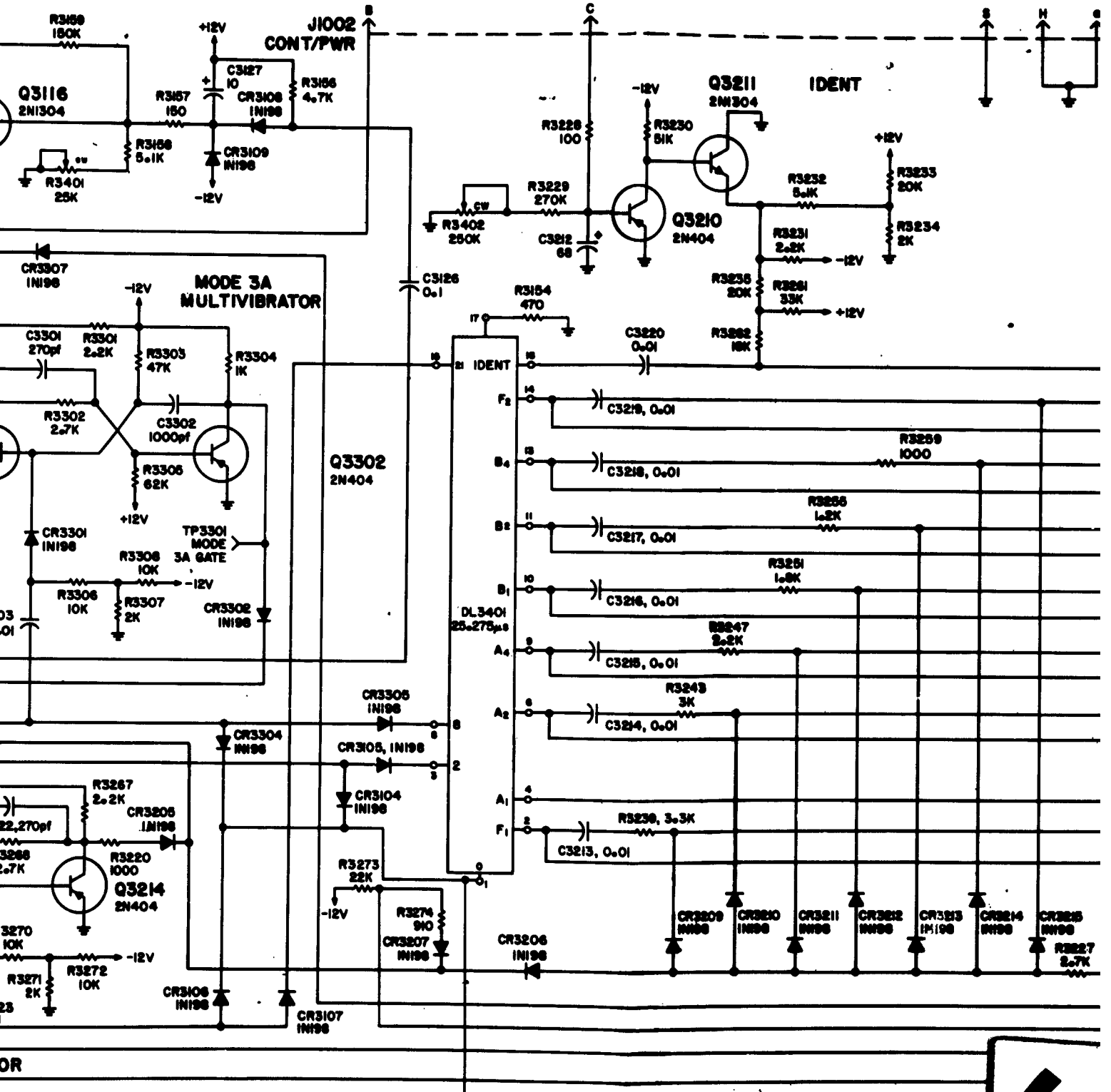


Figure 4. SLATE II Schematic Diagram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CONT/PWR
Q3116
2N1304
Q3211
IDENT
2N1304
Q3210
2N404
MODE 3A
MULTIVIBRATOR
Q3302
2N404
Q3214
2N404
DL3401
25.275μs
IDENT
+12V
-12V
R3159 180K
C3127 10
R3156 4.7K
R3157 150
R3158 5.1K
R3401 25K
CR3108 IN198
CR3109 IN198
R3228 100
R3230 51K
R3229 270K
R3402 250K
C3212 68
R3232 5.1K
R3233 20K
R3234 2K
R3231 2.2K
R3235 20K
R3236 33K
R3262 18K
C3126 0.1
R3154 470
C3220 0.01
CR3307 IN198
C3301 270pf
R3301 2.2K
R3303 47K
R3304 1K
R3302 2.7K
C3302 1000pf
R3305 62K
CR3301 IN198
TP3301 MODE 3A GATE
R3306 10K
R3307 2K
CR3302 IN198
C3219, 0.01
C3218, 0.01
C3217, 0.01
C3216, 0.01
C3215, 0.01
C3214, 0.01
C3213, 0.01
R3259 1000
R3258 1.2K
R3261 1.8K
R3247 2.2K
R3243 3K
R3239, 3.3K
CR3305 IN198
CR3304 IN198
CR3105, IN198
CR3104 IN198
R3267 2.2K
CR3206 IN198
R3220 1000
R3273 22K
R3274 910
CR3207 IN198
CR3206 IN198
CR3106 IN198
CR3107 IN198
CR3209 IN198
CR3210 IN198
CR3211 IN198
CR3212 IN198
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CR3214 IN198
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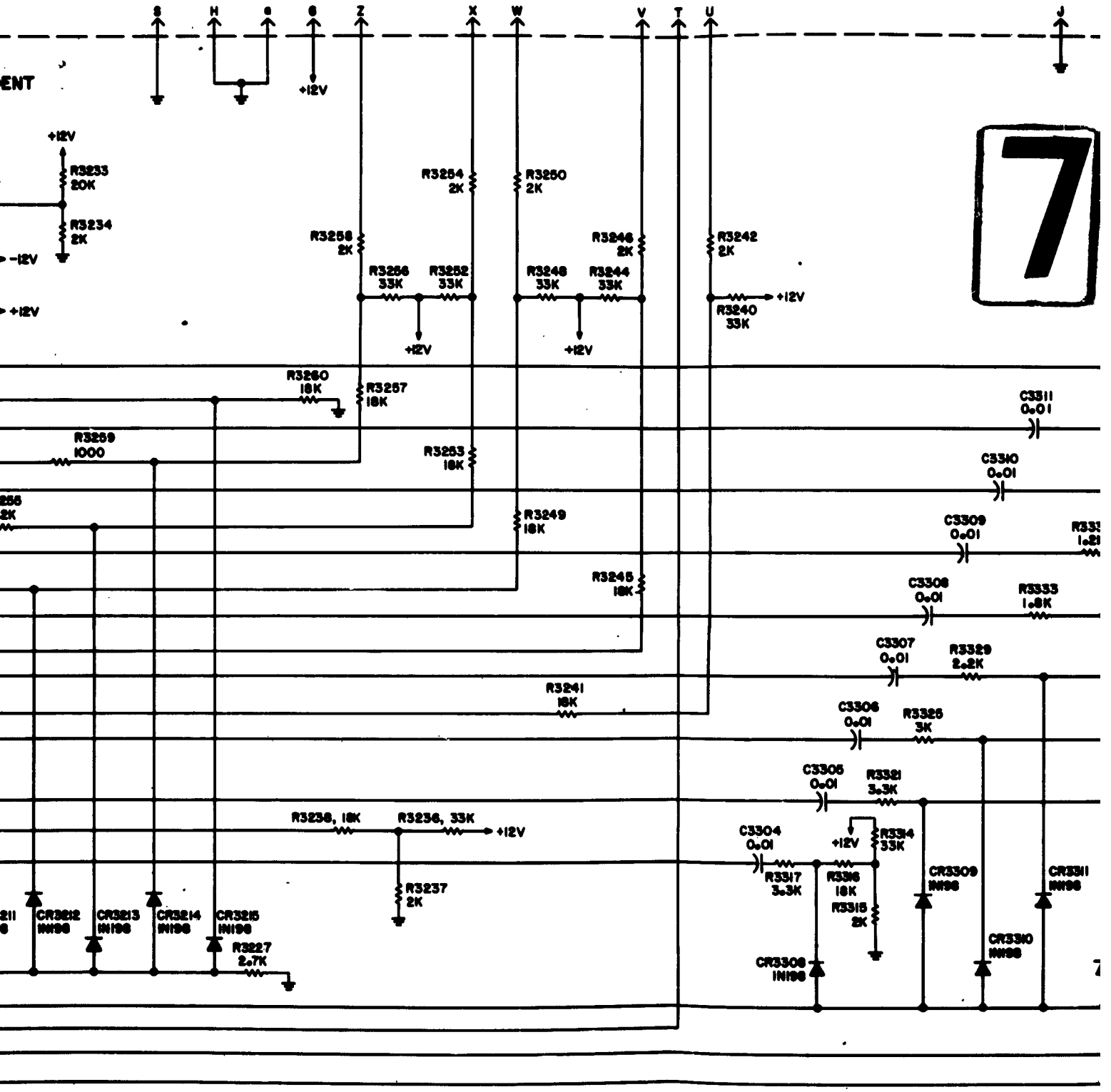
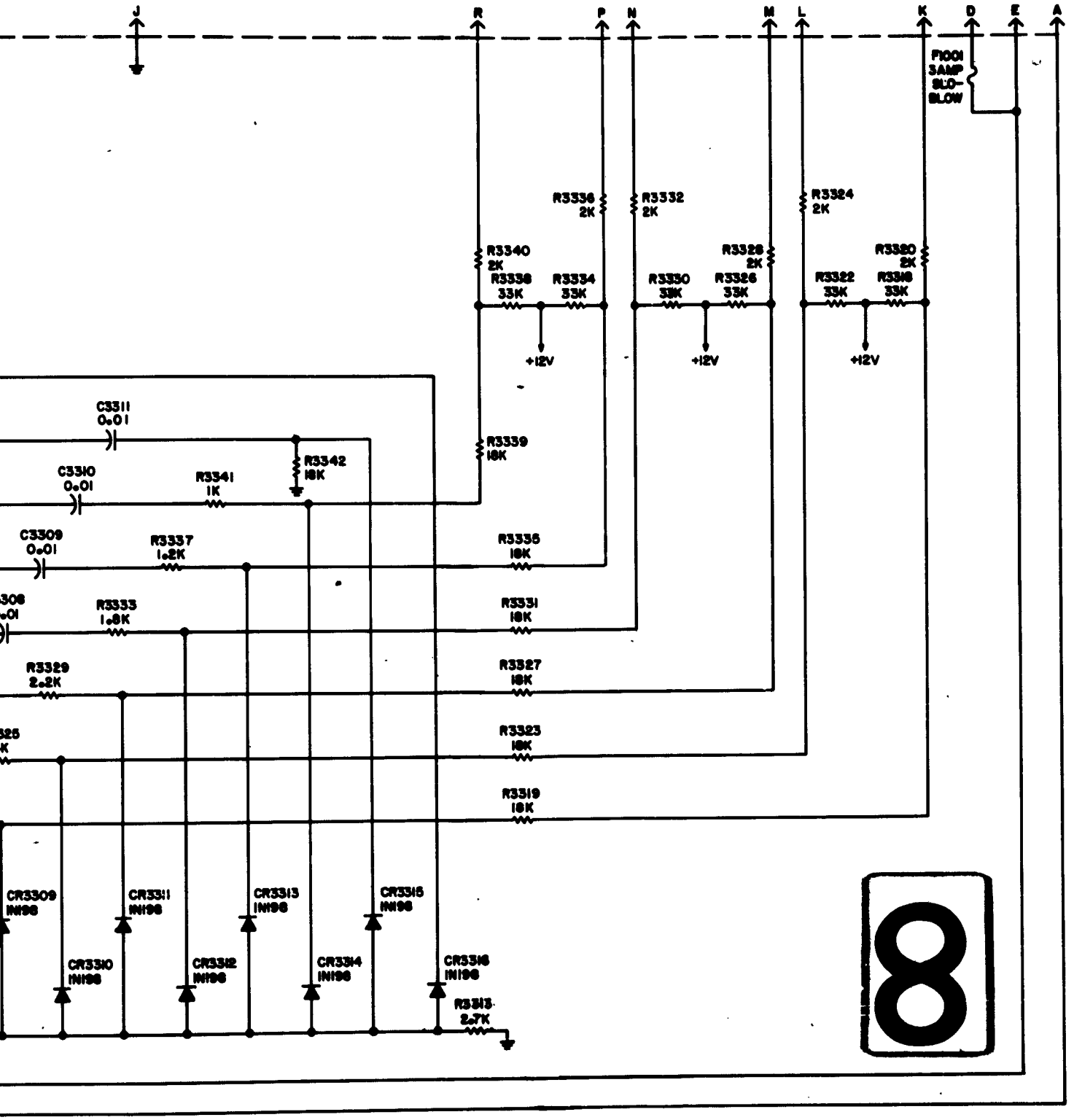
R3270 10K
R3271 2K
R3272 10K

6


S
H
G
G
Z
X
W
V
T
U
J
+12V
R3233 20K
R3234 2K
-12V
+12V
R3254 2K
R3250 2K
R3258 2K
R3246 2K
R3242 2K
R3256 33K
R3252 33K
R3248 33K
R3244 33K
+12V
R3240 33K
+12V
+12V
+12V
R3260 18K
R3257 18K
R3259 1000
R3253 18K
R3249 18K
R3245 18K
R3241 18K
R3238, 18K
R3236, 33K
+12V
R3237 2K
CR3212 IN198
CR3213 IN198
CR3214 IN198
CR3215 IN198
R3227 2.7K
C3311 0.01
C3310 0.01
C3309 0.01
C3308 0.01
R3333 1.8K
C3307 0.01
R3329 2.2K
C3306 0.01
R3326 3K
C3305 0.01
R3321 3.3K
C3304 0.01
+12V
R3314 33K
R3317 3.3K
R3316 18K
R3315 2K
CR3309 IN198
CR3311 IN198
CR3310 IN198
CR3308 IN198
7


J
R
P
N
M
L
K
D
E
A
F1001
3AMP
SLO-
BLOW
R3336
2K
R3332
2K
R3324
2K
R3340
2K
R3328
2K
R3320
2K
R3338
33K
R3334
33K
R3330
33K
R3326
33K
R3322
33K
R3318
33K
+12V
+12V
+12V
C3311
0.01
C3310
0.01
R3341
1K
R3342
18K
R3339
18K
C3309
0.01
R3337
1.2K
R3335
18K
R3333
1.8K
R3331
18K
R3329
2.2K
R3327
18K
R3323
18K
R3319
18K
CR3309
IN198
CR3311
IN198
CR3313
IN198
CR3315
IN198
CR3310
IN198
CR3312
IN198
CR3314
IN198
CR3316
IN198
R3313
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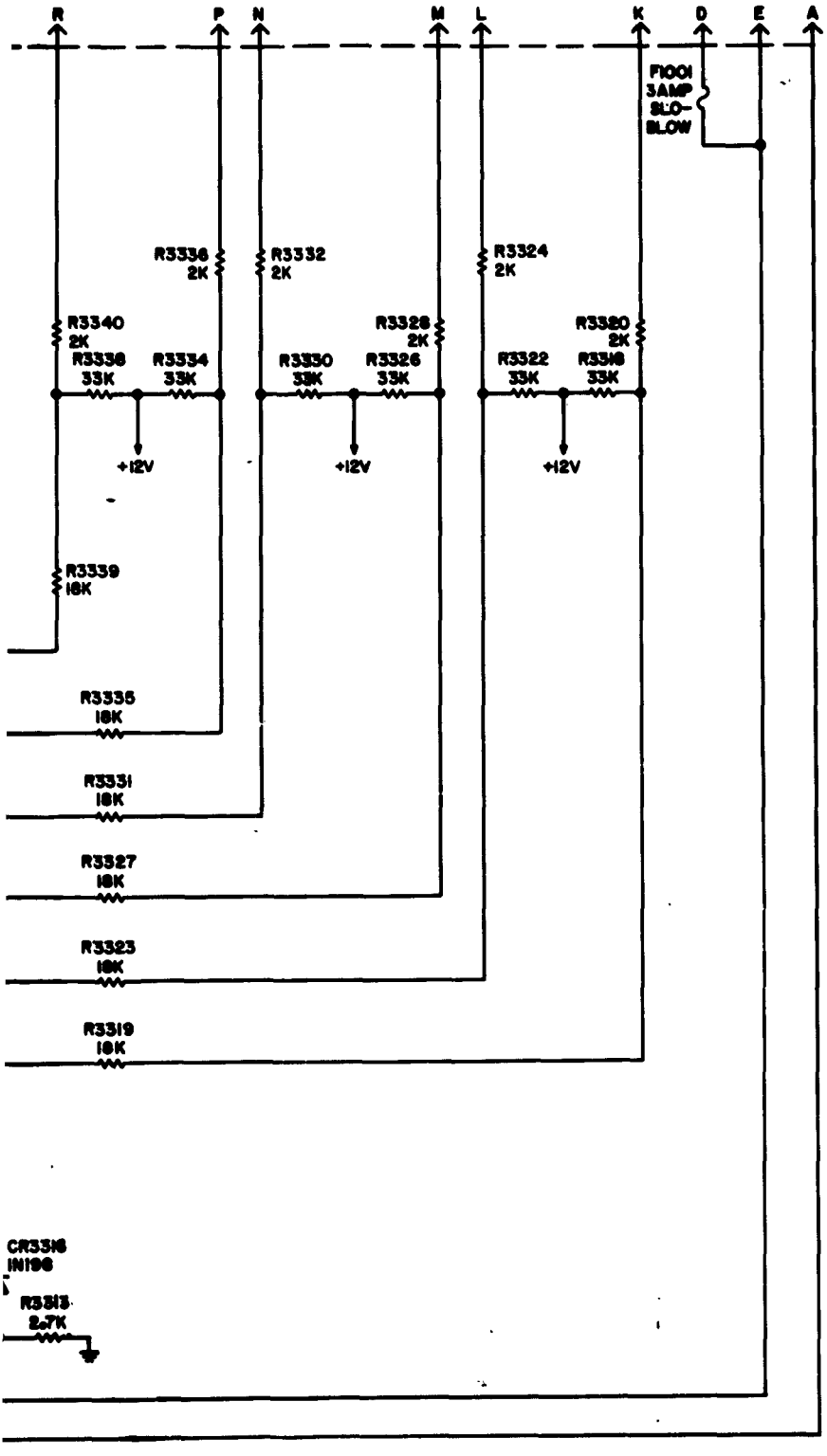
8



SLATE 11

HAZELTINE
SMALL LIGHT-WEIGHT ALTITUDE TRANSMISSION EQUIPMENT

UNLESS OTHERWISE NOTED:

1. RESISTANCES ARE SHOWN IN OHMS, CAPACITANCES ARE SHOWN IN MICROFARADS
2. 9 TURNS NO. 28 WIRE
3. SHORTED QUARTER-WAVELENGTH LINE
4. RELAYS SHOWN IN DE-ENERGIZED CONDITION

9

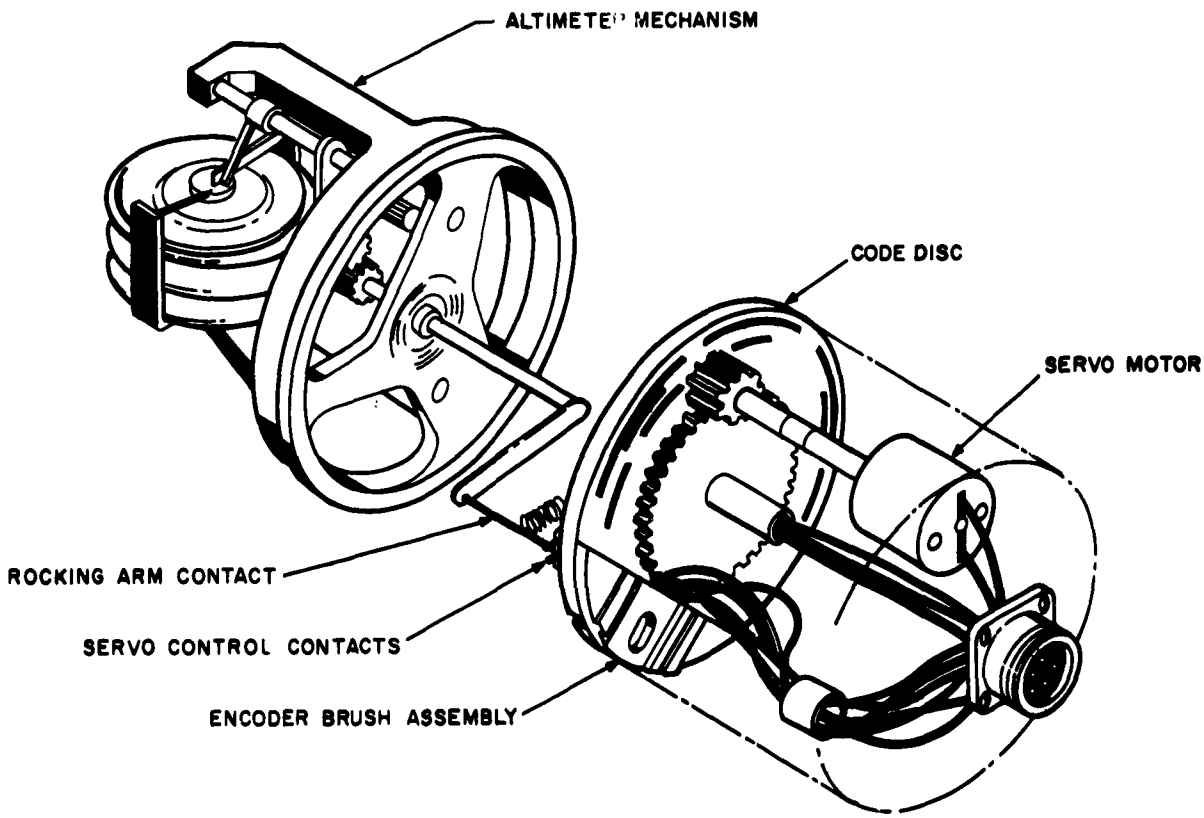
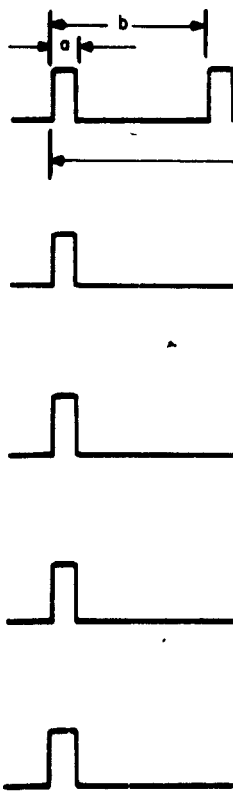


Figure 5. Altitude Transducer, Exploded View

CONDITIONS:

SLATE	INTERROGATION MODE	CODE SELECTOR SETTING	ALTITUDE ABOVE SEA LEVEL	IDENTIFICATION BUTTON DEPRESSED	FRAMING PULSE AI PUL
II	3/A	77	ANY	YES	
II	3/A	00	ANY	YES	
I	C		ANY	YES	
I	C		1,500	NO	
II	C	ANY	1,500	YES OR NO	



LEGEND :
a = 0.45 MICROSECONDS
b = 2.9 MICROSECONDS
c = 20.3 MICROSECONDS
d = 4.35 MICROSECONDS

Figure 6. SLATE

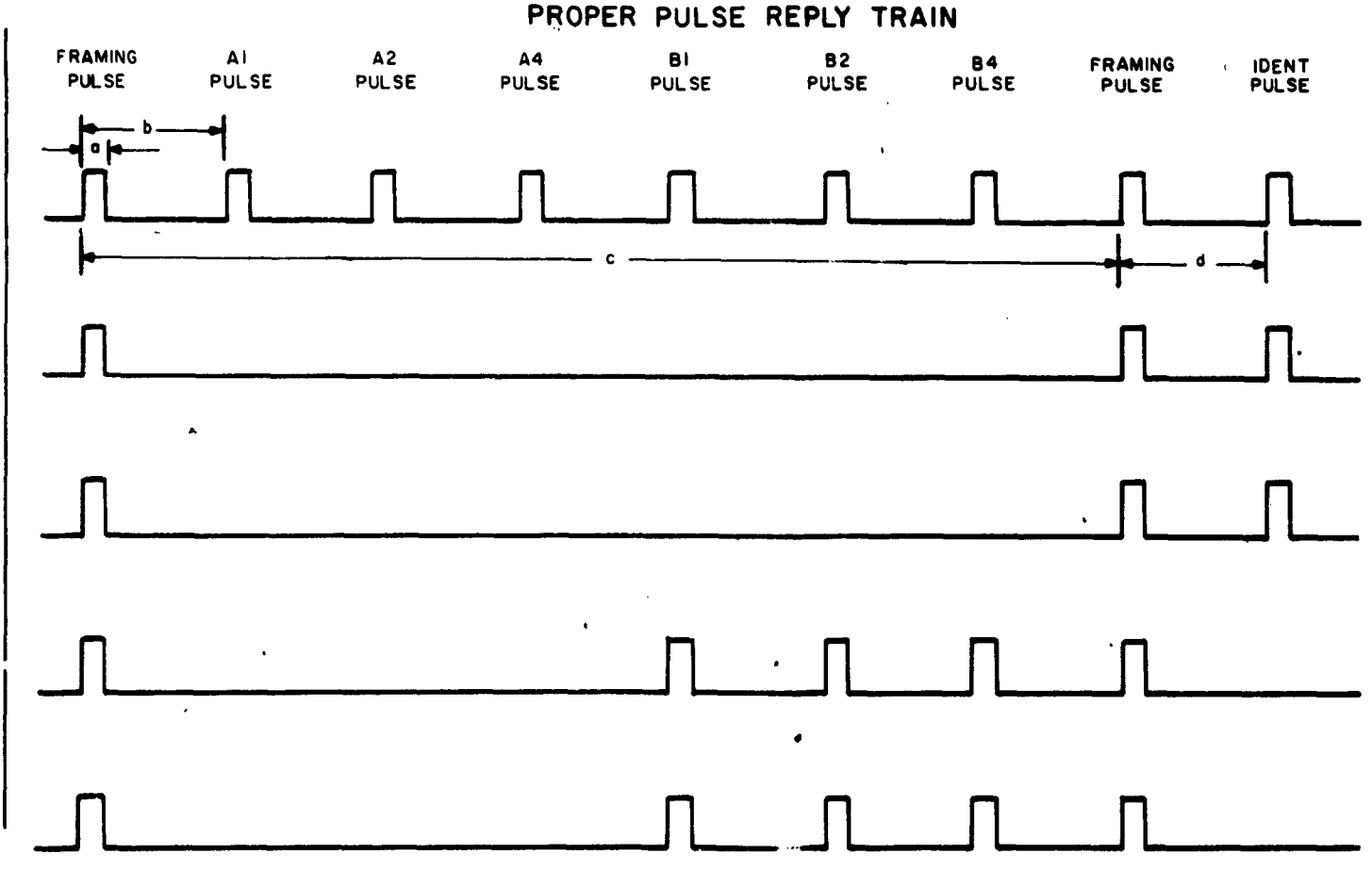


Figure 6. SLATE Reply Pulses

APPENDIX I

SPECIFICATIONS[1]

A. GENERAL

Transmitter Frequency:	1090mc (nominal)
Receiver Frequency:	1030mc (nominal)
Altitude:	15,000 feet (maximum)
Temperature:	-10° C to +55° C (operating -40° C to -10° C (operation for a +55° C to +70° C short period) -65° C (storage - non-operating)
Power:	13.75 volts d-c +10% -20% at 1.5 amperes (no signal), 1.6 amperes at maximum duty cycle
Transistors:	
SLATE I:	48
SLATE II:	50
Vacuum Tubes	2

B. TRANSMITTER-RECEIVER

Transmitter Power Output:	32 watts peak (minimum)
Transmitter Frequency Stability:Ω	±3mc
Receiver Sensitivity:	-60dbm (minimum)
Receiver Bandwidth:	3db down, greater than 6mc 40db down, less than 50mc

[1] Unless otherwise specified, all specifications are equally applicable to Hazeltine SLATE I and SLATE II.

Reply Codes:	
SLATE I:	Any one of 33 altitude codes or Code 00 plus the IDENT pulse
SLATE II:	Mode C interrogation - any one of 33 altitude codes (never an IDENT pulse)
	Mode 3A interrogation - Codes 00 through 77 (64 codes) plus the IDENT pulse
Side Lobe Suppression:	Three-pulse
Side Lobe Suppression Selectivity:	2.0 ± 0.15 microsecond - 100% suppression 2.0 ± 1.0 microsecond - no suppression
Decoding Selectivity:	
SLATE I:	Accept pulses spaced 21.0 ±0.20 microseconds Reject pulses spaced 21.0 ±1.0 microseconds
SLATE II:	Accept pulses spaced 8.0 ±0.20 microseconds and 21.0 ±0.20 microseconds
	Reject pulses spaced 8.0 ±1.0 microseconds and 21.0 ±1.0 microseconds
Reply Pulse Spacing Accuracy:	±0.1 microsecond, except that the tolerance of any pulse with respect to any other pulse in the train shall not exceed ±0.15 microsecond
Weight:	9.5 pounds
Size:	3-9/16 inches wide, 7-9/16 inches high, 12-3/4 inches deep

C. CONTROL PANEL (SLATE I)

Weight:	1.5 ounces
Front Panel Size	2 inches high - 3.5 inches wide

D. CONTROL BOX (SLATE II)

Weight:	12 ounces
Front Panel Size:	3-3/16 inches square (rear section fits 3-1/16-inch aircraft instrument panel mounting hole)
Overall Length:	3 inches (excluding connector and front panel projections)

E. ANTENNA

Weight:	1 ounce
Size:	4 inches long by 1 inch square (maximum)

APPENDIX II

TEST DATA

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477 TYPE
Serial No. 1
Measured by
Witnessed by
Date 3 Sept. 62

Standard Test Conditions:

Temperature: Room Temp.

Primary Power Input Voltage: 13.5 VDC

Humidity: Normal

Vibration: None

Interrogation Signal:

a. Pulse duration:- $0.8 \pm .1$ usec
b. Pulse rise time:- $.05 < t_r < .1$ usec
c. Pulse fall time:- $.05 < t_f < .2$ usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum -16 dbm
(2) Maximum -78 dbm
(3) Final Setting -64 dbm (-60 to -68 dbm)

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 1)

FREQ (MC)	MTL (-dbm) (90% reply)	▲db from 1030 MC
1030	-64	0
1026	-60	4
1020	-44	20

1010	-25	39
1005	-15	49
1000	-4	60
1034	-60	4
1040	-44	20
1045	-32	32
1055	-19	45
1058.25	-10	54
1060	-9	55
1148.28	> +4	> 68

3. Receiver Spurious Responses

   a. Image > 68 db down

   b. Other 54 db down at 1058.25 mc

4. Side Lobe Suppression Characteristics (See graph 2)

Interrogation Level		SLS Pulse (P_2)-dbm	
P_1	P_3(-dbm)	10% reply	90% reply
64		64	65
60		61.5	62.5
55		56.5	57
50		51	51.5
45		46	46.5
40		41	41^+
35		37	37^+
30		33.5	34
25		30	30.5
20		27	27.5
15			

5. Echo Recovery Linearity and Period (See graph 3)

Single Pulse Level - dbm	Single Pulse Spacing , usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensiti-zation
-45	2	-48	16
	3	-50	14
	4	-52.5	11.5
	5	-55	9
	6	-57	7
	7	-60.5	3.5
	8	-63	1
	9		
-25	3	-38	26
	4	-39.5	24.5
	6	-42.5	21.5
	8	-46.5	17.5
	11	-53.5	10.5
	13	-58.5	5.5
	14	-61.5	2.5
	15		

6. Mode (Decoding Selectivity)

   a. 3 db above MTL

      (1) 90% Reply from 20.72 to 21.46 usec (21 ± .20 usec)
      (2) 10% Reply when less than 20.67 (20 usec) or greater than 21.50 usec (22 usec)

   b. -25 dbm signal

      (1) 90% Reply from 20.36 to 21.59 usec
      (2) 10% Reply when less than 20.31 or greater than 21.64 usec

7. Side Lobe Suppression Decoding Selectivity

   a. 3 db above MTL

      (1) 90% Suppression from 1.69 to 2.41 usec (2 ± .15 usec)
      (2) 10% Suppression when less than 1.58 (1 usec) or greater than 2.50 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.37 to 2.61 usec
(2) 10% Suppression when less than 1.27 or greater than 2.67 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (-61 dbm)	-53 dbm
10 (-54 dbm)	-44 dbm
20 (-44 dbm)	-37 dbm
40 (-24 dbm)	-28 dbm

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1) MTL Suppression no, Interrogation no
(2) -50 dbm Suppression no, Interrogation no
(3) -25 dbm Suppression no, Interrogation no

9. Side Lobe Suppression Duration and Recovery

a. Suppression Duration 31 usec (< 45 usec)
b. Suppression Recovery 1.7 usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

a. Amplitude Jitter
(1) 500 replies/sec. < 1%

b. Variation in amplitude between pulses
(1) 500 replies/sec. 1%

c. Output Power
(1) 500 replies/sec. 44.2 watts peak

d. Transmitter Frequency 1090.0 mc

11. Reply Pulse Characteristics

	MAXIMUM	MINIMUM
a. Rise Time	.055 usec	.05 usec (.05 t_r < .1 usec)
b. Decay Time	.17 usec	.16 usec (.05< t_f < .2 usec)
c. Duration	.46 usec	.45 usec (.45 ±1 usec)

12. Overall Transponder Delay

(7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	2.95 (3 ± .5 usec)
-25 dbm	2.7 (3 ± .5 usec)

13. Transponder Dead Time < 36 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A2	5.80 usec (5.8)	0	usec
A4	8.72 usec (8.7)	+.02	usec
B1	11.62 usec (11.6)	+.02	usec
B2	14.51 usec (14.5)	+.01	usec
B4	17.40 usec (17.4)	0	usec
F2	20.30 usec (20.3)	0	usec
IDENT	— usec (24.65)		

15. Duration of I/P Pulse Transmission

a. Minimum 12 sec.

b. Maximum 21 sec.

c. Final Setting 15 sec.

16. Automatic Overload Control (Reference 500 prf input)

    a. Sensitivity reduction at 750 prf input

       30 db at 675 replies/sec.

    b. Sensitivity reduction at 450 prf input

       2.5 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

    a. Input Voltage 27.5 V.D.C.

    b. Input Voltage 13.5 V.D.C. 1.45 amperes

MODE 3A

1. Mode 3A Decoding Selectivity Delay at -60 dbm 2.97

    a. 3 db above MTL

       (1) 90% reply from 7.51 to 8.40 usec (8 ±.2)
       (2) 10% reply when less than 7.48 7 usec or greater than 8.45 9 usec.

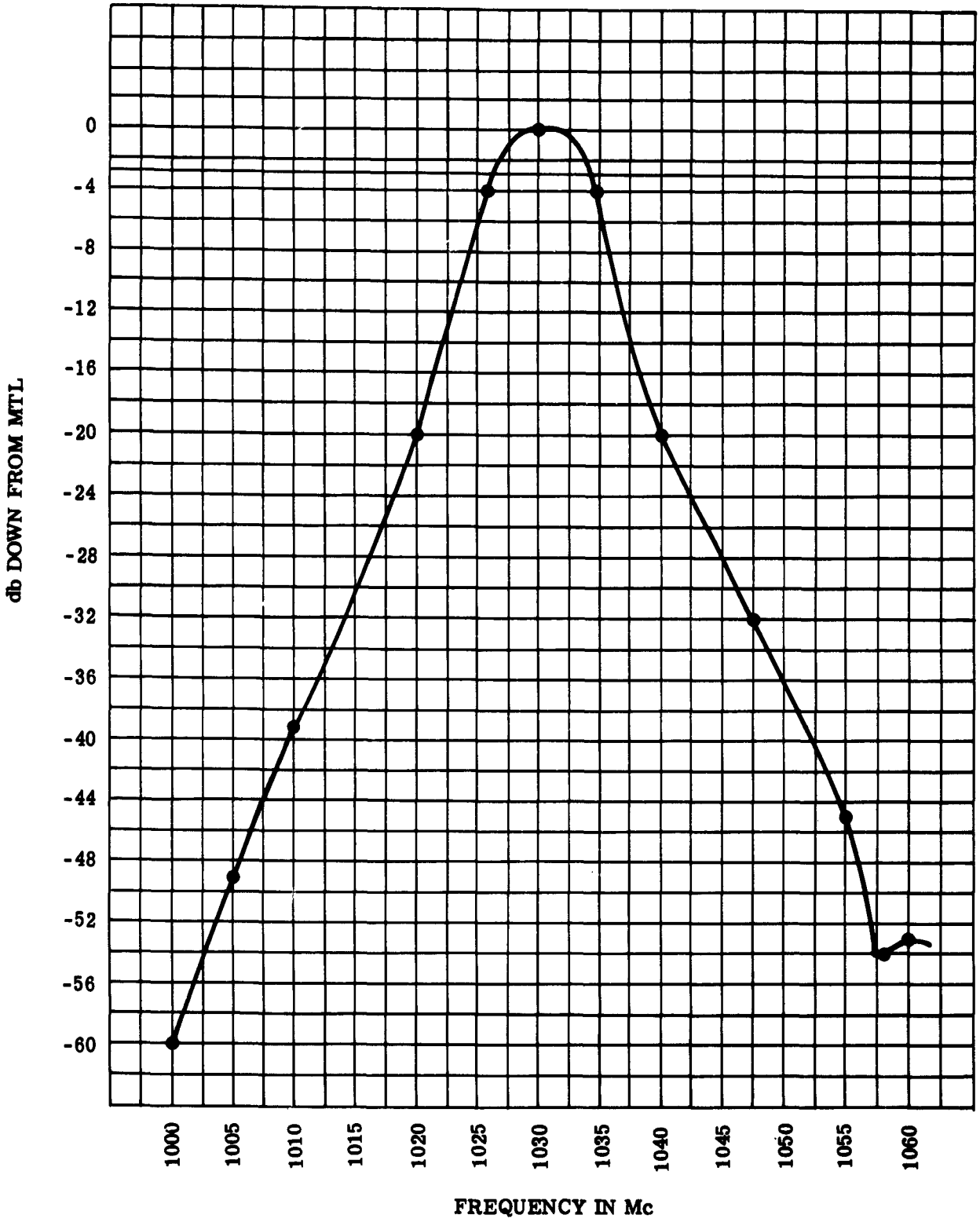
    b. -25 dbm Signal

       (1) 90% reply from 7.25 to 8.45 usec
       (2) 10% reply when less than 7.21 or greater than 8.52 usec

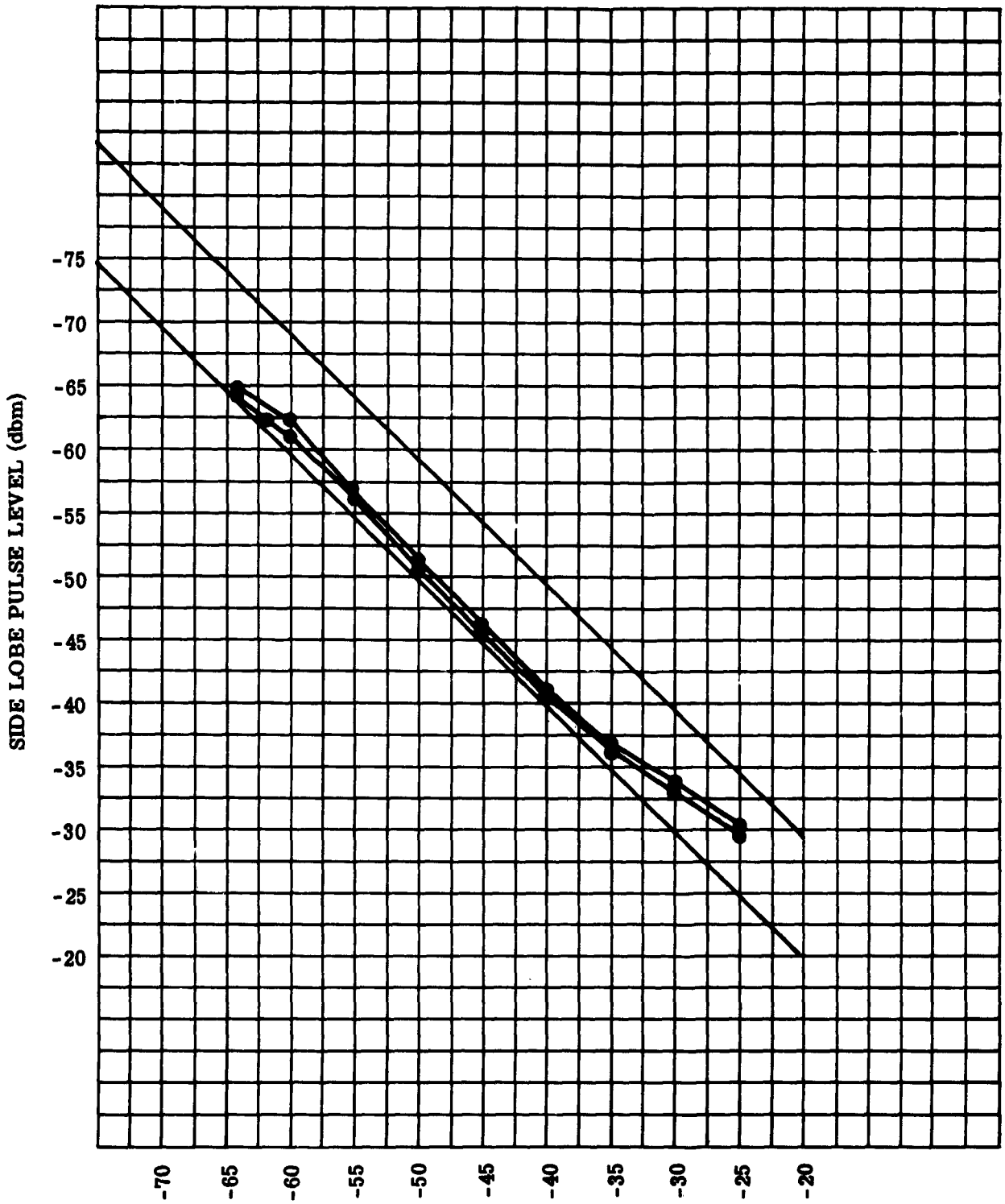
2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

DISTANCE FROM F1	TOLERANCE DEVIATION ±.1
A1 2.94 usec (2.9)	+.04 usec
A2 5.84 usec (5.8)	+.04 usec
A4 8.73 usec (8.7)	+.03 usec
B1 11.63 usec (11.6)	+.03 usec
B2 14.52 usec (14.5)	+.02 usec

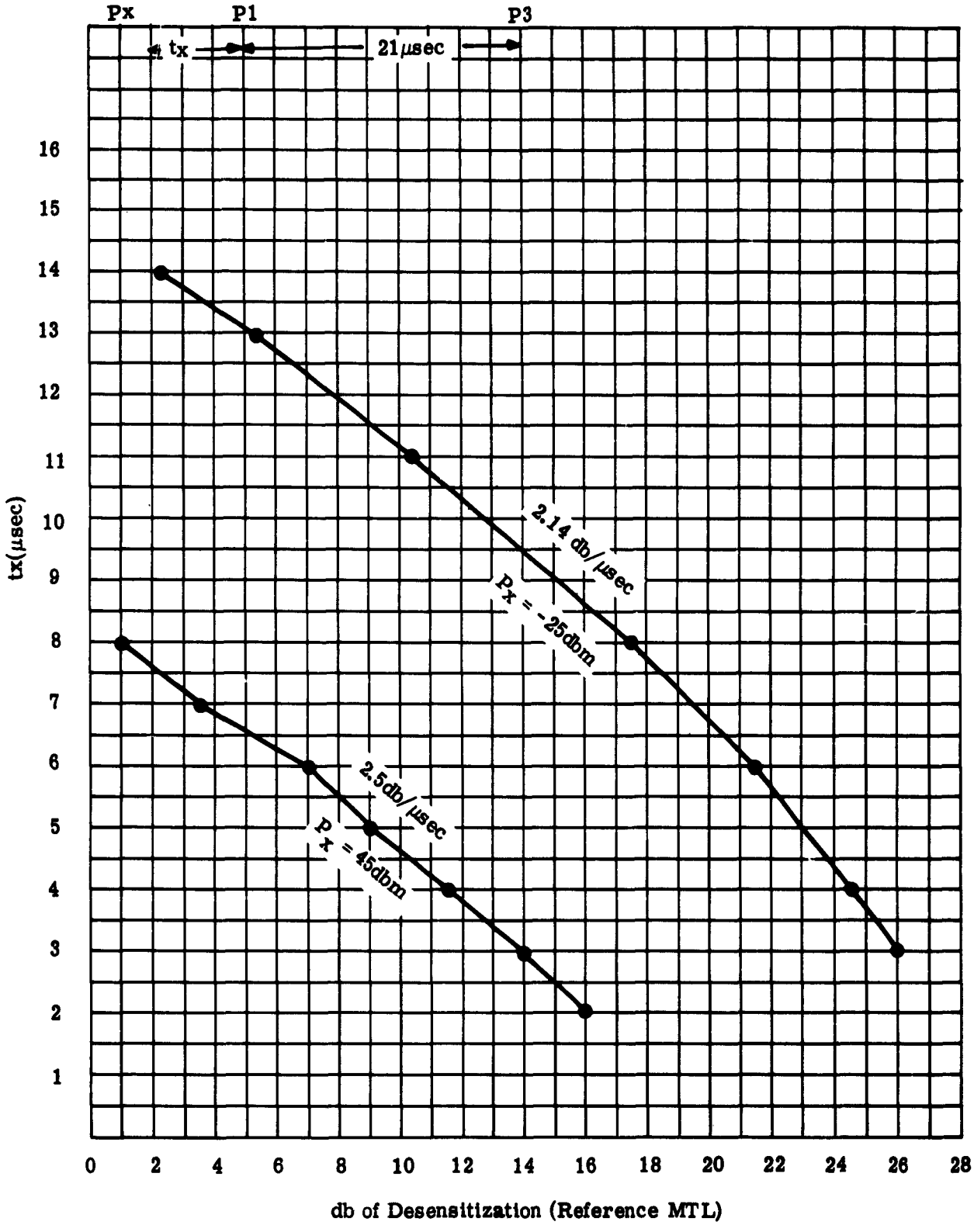
B4	17.42 usec (17.4)	+.02 usec
F2	20.31 usec (20.3)	+.01 usec
IDENT	24.63 usec (24.65)	-.02 usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 1)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 2)



ECHO RECOVERY AND PERIOD (GRAPH 3)

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477 TYPE
Serial No. 1
Measured by
Witnessed by
Date 14 Sept.

Standard Test Conditions:

Temperature: +5.5°C

Primary Power Input Voltage: 14.85

Humidity: Normal

Vibration: None

Interrogation Signal:

a. Pulse duration:- 0.8 $\pm$.1 usec
b. Pulse rise time:- .05 < t_r < .1 usec
c. Pulse fall time:- .05 < t_f < .2 usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting 63 dbm (-60 to -68 dbm) at 200 prf

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 4)

FREQ (MC)	MTL (-dbm) (90% reply)	▲db from 1030 MC
1030	-63	0
1034	-61	2
1034.3	-60	3

1040	-46	17
1050	-19	44
1058	-1	62
1026	-58	5
1026.9	60	3
1020	-43	-20
1010	-15	-48
1005	-4	-59

3. Receiver Spurious Responses

   a. Image 58 db down

   b. Other db down at mc

4. Side Lobe Suppression Characteristics (See graph 5)

Interrogation Level P_1 P_3 (-dbm)	SLS Pulse (P_2)-dbm 10% reply	90% reply
-61 (M.D.L)	-61+	-63
60	-60.5	-61.5
55	-56.5	-57
50	-51	-51.5
45	-46	-46+
40	-41	-41+
35	-36	-36.5
30	-33	-33.5
25	-29.5	-30
20	-26.5	-27.5
15		

5. Echo Recovery Linearity and Period (See graph 6)

Single Pulse Level - dbm	Single Pulse Spacing, usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	49.5	11.0
	3	52	8.5
	4	55.5	5.0
	5	58.5	2.0
	6	60	0.5
-25	3	37	23.5
	4	39	21.5
	6	44	16.5
	8	49.5	11.0
	11	51.5	9.5
	13	57	5.5
	14	59.5	2.0

6. Mode (Decoding Selectivity)

a. 3 db above MTL Data taken at 300 prf

(1) 90% Reply from 20.77 to 21.61 usec (21 ±.20 usec)
(2) 10% Reply when less than 20.69 (20 usec) or greater than 21.67 usec (22 usec)

b. -25 dbm signal

(1) 90% Reply from 20.60 to 21.78 usec
(2) 10% Reply when less than 20.52 or greater than 21.85 usec

7. Side Lobe Suppression Decoding Selectivity

a. 3 db above MTL

(1) 90% Suppression from 1.62 to 2.50 usec (2 ±.15 usec)
(2) 10% Suppression when less than 1.55 (1 usec) or greater than 2.54 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.37 to 2.87 usec
(2) 10% Suppression when less than 1.34 or greater than 2.96 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1.

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (-57)	-55
10 (-50)	46
20 (-40)	35
40 (-20)	25

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1) MTL Suppression no, Interrogation no
(2) -50 dbm Suppression no, Interrogation no
(3) -25 dbm Suppression no, Interrogation no

9. Side Lobe Suppression Duration and Recovery

a. Suppression Duration < 30 usec (< 45 usec)
b. Suppression Recovery 1.85 usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

a. Amplitude Jitter
(1) 500 replies/sec. < 1%

b. Variation in amplitude between pulses
(1) 500 replies/sec. < 1%

c. Output Power
(1) 100 replies/sec. watts peak
(2) 500 replies/sec. 47.1 watts peak

d. Transmitter Frequency 1091.9 mc

11. Reply Pulse Characteristics

	MAXIMUM	MINIMUM
a. Rise Time	.055 usec	.05 usec (.05 t_r < .1 usec)
b. Decay Time	.19 usec	.17 usec (.05<t_f < .2 usec)
d. Duration	.55 usec	.54 usec (.45 ±.1 usec)

12. Overall Transponder Delay

(7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	3.2 (3 ±.5 usec)
-25 dbm	3.05 (3 ±.5 usec)

13. Transponder Dead Time < 35 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ±.1	
A2	usec (5.8)	-.01	usec
A4	usec (8.7)	+.01	usec
B1	usec (11.6)	0	usec
B2	usec (14.5)	0	usec
B4	usec (17.4)	-.01	usec
F2	usec (20.3)	-.02	usec
IDENT	usec (24.65)		

15. Duration of I/P Pulse Transmission

a. Minimum sec.

b. Maximum sec.

c. Final Setting 12 sec.

16. Automatic Overload Control (Reference 500 prf input)

a. Sensitivity reduction at 750 prf input

32 db. at 671 replies/sec.

b. Sensitivity reduction at 450 prf input

1.5 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

a. Input Voltage 27.5 V.D.C. amperes

b. Input Voltage 14.5 V.D.C. 1.82 amperes

MODE 3A

1. Mode 3A Decoding Selectivity

a. 3 db above MTL

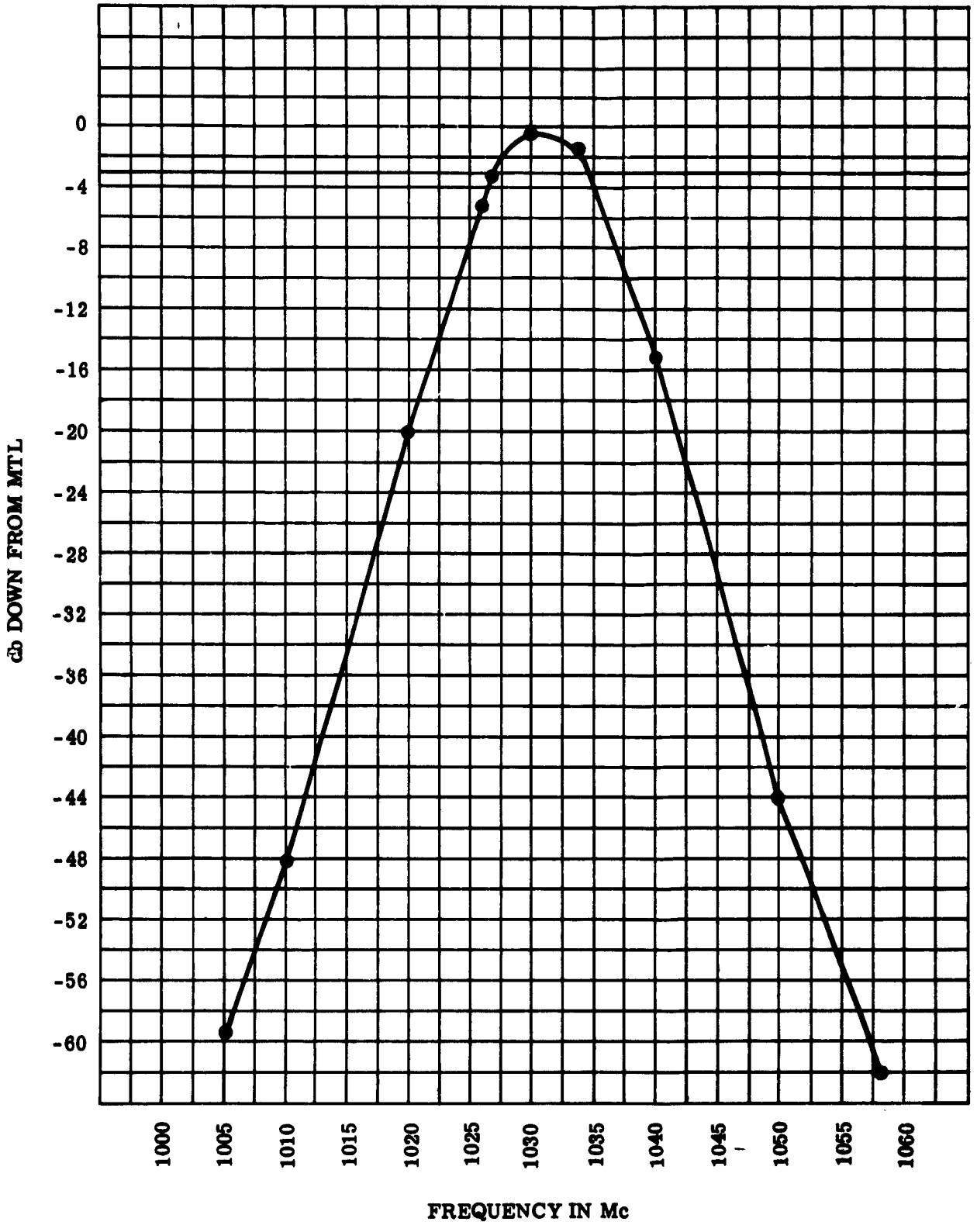
(1) 90% reply from 7.48 to 8.39 usec (8 ±.2)
(2) 10% reply when less than 7.40 7 usec or greater than 8.48 9 usec.

b. -25 dbm Signal

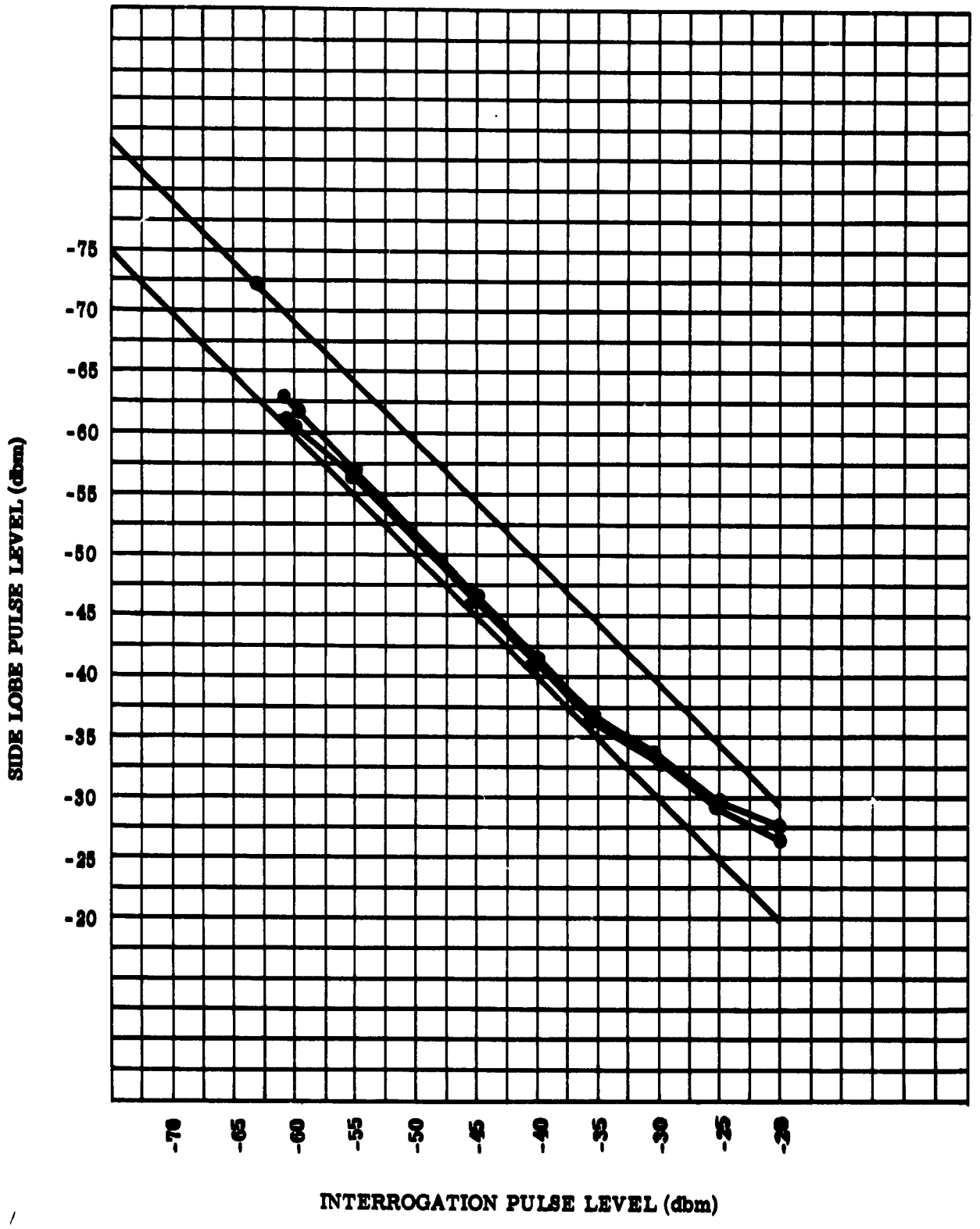
(1) 90% reply from 7.32 to 8.60 usec.
(2) 10% reply when less than 7.24 or greater than 8.65 usec.

2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

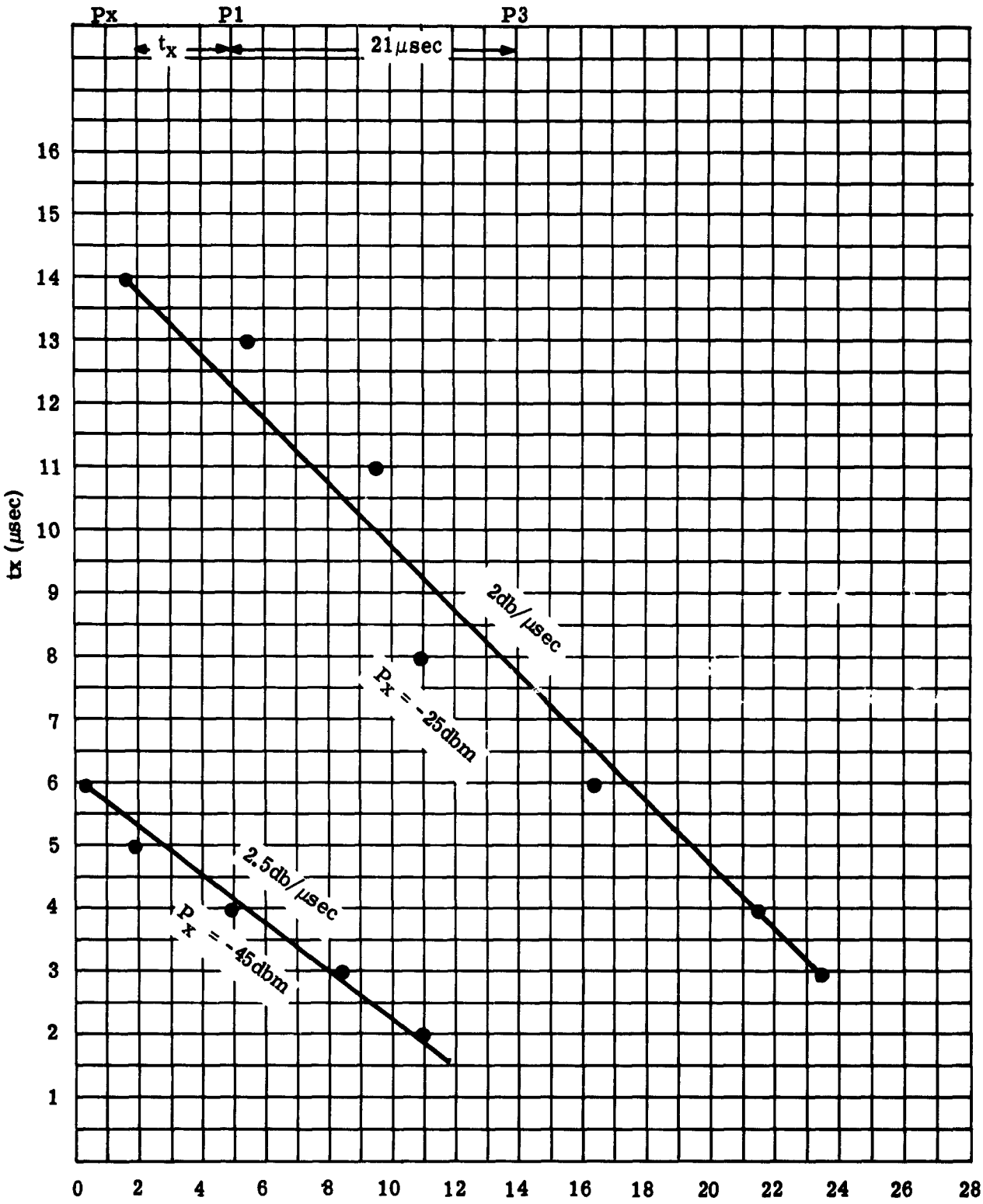
DISTANCE FROM F1		TOLERANCE DEVIATION ±.1
A1	usec (2.9)	+.02 usec
A2	usec (5.8)	+.01 usec
A4	usec (8.7)	0 usec
B1	usec (11.6)	-.01 usec
B2	usec (14.5)	-.02 usec
B4	usec (17.4)	-.03 usec
F2	usec (20.3)	-.04 usec
IDENT	usec (24.65)	-.08 usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 4)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 5)



ECHO RECOVERY AND PERIOD (GRAPH 6)

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477 TYPE
Serial No. 1

Measured by
Witnessed by
Date

Standard Test Conditions:

Temperature: -15°C

Primary Power Input Voltage: 12.15 VDC

Humidity: Normal

Vibration: None

Interrogation Signal:

a. Pulse duration:- 0.8 ±.1 usec
b. Pulse rise time:- .05 < t_r < .1 usec
c. Pulse fall time:- .05 < t_f < .2 usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting -66 dbm (-60 to -68 dbm) at 200 prf

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 7)

FREQ (MD)	MTL (-dbm) (90% reply)	Δ db from 1030 MC
1030	-66	0
1033.4	63	3
1026	65	1

1020	-48	18
1010	-27	39
1005	-15	51
1040	-50	16
1050	-26	40
1055	-10	56
1147.332	-8	58

3. Receiver Spurious Responses

   a. Image -58 db down

   b. Other db down at mc

4. Side Lobe Suppression Characteristics (See graph 8)

Interrogation Level P_1	P_3(-dbm)	SLS Pulse (P_2)-dbm 10% reply	90% reply
66	(MTL)	67	68
60		61	61.5
55		55.5	56
50		51	51+
45		46	46+
40		41	41.5
35		37	37.5
30		32	32.5
25		27.5	28.5
20			
15			

5. Echo Recovery Linearity and Period (See graph 9)

Single Pulse Level - dbm	Single Pulse Spacing, usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	47.5	18.5
	3	49.5	16.5
	4	51.5	14.5
	5	53	13
	6	55	11
	7	57.5	
	8	59	7
	9	61	5
	10	63.5	2.5
-25	3	40	26
	4	42	24
	6	44.5	21.5
	8	48	18
	11	55	11
	13	57	9
	14	59	7
	15	61	5
	16	64	2

6. Mode (Decoding Selectivity)

a. 3 db. above MTL

(1) 90% Reply from 20.60 to 21.42 usec (21 ±.20 usec)
(2) 10% Reply when less than 20.56 (20 usec) or greater than 21.46 usec (22 usec)

b. -25 dbm signal

(1) 90% Reply from 20.40 to 21.60 usec
(2) 10% Reply when less than 20.35 or greater than 21.63 usec

7. Side Lobe Suppression Decoding Selectivity

a. 3 db above MTL

(1) 90% Suppression from 1.72 to 2.44 usec (2 ±.15 usec)
(2) 10% Suppression when less than 1.58 (1 usec) or greater than 2.49 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.80 to 2.39 usec
(2) 10% Suppression when less than 1.75 or greater than 2.46 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (63)	-58.5
10 (56)	-50 dbm
20 (46)	-41 dbm
40 (26)	-29 dbm

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1) MTL Suppression no, Interrogation no
(2) -50 dbm Suppression no, Interrogation no
(3) -25 dbm Suppression no, Interrogation no

9. Side Lobe Suppression Duration and Recovery

a. Suppression Duration 31 usec (< 45 usec)
b. Suppression Recovery 1.9 usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train) 500 prf

a. Amplitude Jitter
(1) 500 replies/sec. < 1%

b. Variation in amplitude between pulses
(1) 500 replies/sec. < 1%

c. Output Power
(1) 100 replies/sec. watts peak
(2) 500 replies/sec. 37.1 watts peak

d. Transmitter Frequency 1088.7 mc

11. Reply Pulse Characteristics

	MAXIMUM	MINIMUM
a. Rise Time	.055 usec	.05 usec (.05 t_r < .1 usec)
b. Decay Time	.195 usec	.20 usec (.05< t_f < .2 usec)
c. Duration	.36 usec	.35 usec (.45 ±.1 usec)

12. Overall Transponder Delay

(7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	2.80 (3 ±.5 usec)
-25 dbm	2.70 (3 ±.5 usec)

13. Transponder Dead Time < 36 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1	TOLERANCE DEVIATION ±.1
A2 usec (5.8)	0 usec
A4 usec (8.7)	0 usec
B1 usec (11.6)	+.01 usec
B2 usec (14.5)	-.01 usec
B4 usec (17.4)	-.02 usec
F2 usec (20.3)	-.03 usec
IDENT usec (24.65)	

15. Duration of I/P Pulse Transmission

a. Minimum sec.

b. Maximum sec.

c. Final Setting 20 sec.

16. Automatic Overload Control (Reference 500 prf input)

a. Sensitivity reduction at 800 prf input

30 db. at 720 replies/sec.

b. Sensitivity reduction at 450 prf input

.5 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

a. Input Voltage 27.5 V.D.C. amperes

b. Input Voltage 12.15 V.D.C. 1.40 amperes

MODE 3A

1. Mode 3A Decoding Selectivity

a. 3 db above MTL

(1) 90% reply from 7.54 to 8.45 usec (8 ±.2)
(2) 10% reply when less than 7.50 7 usec or greater than 8.50 9 usec.

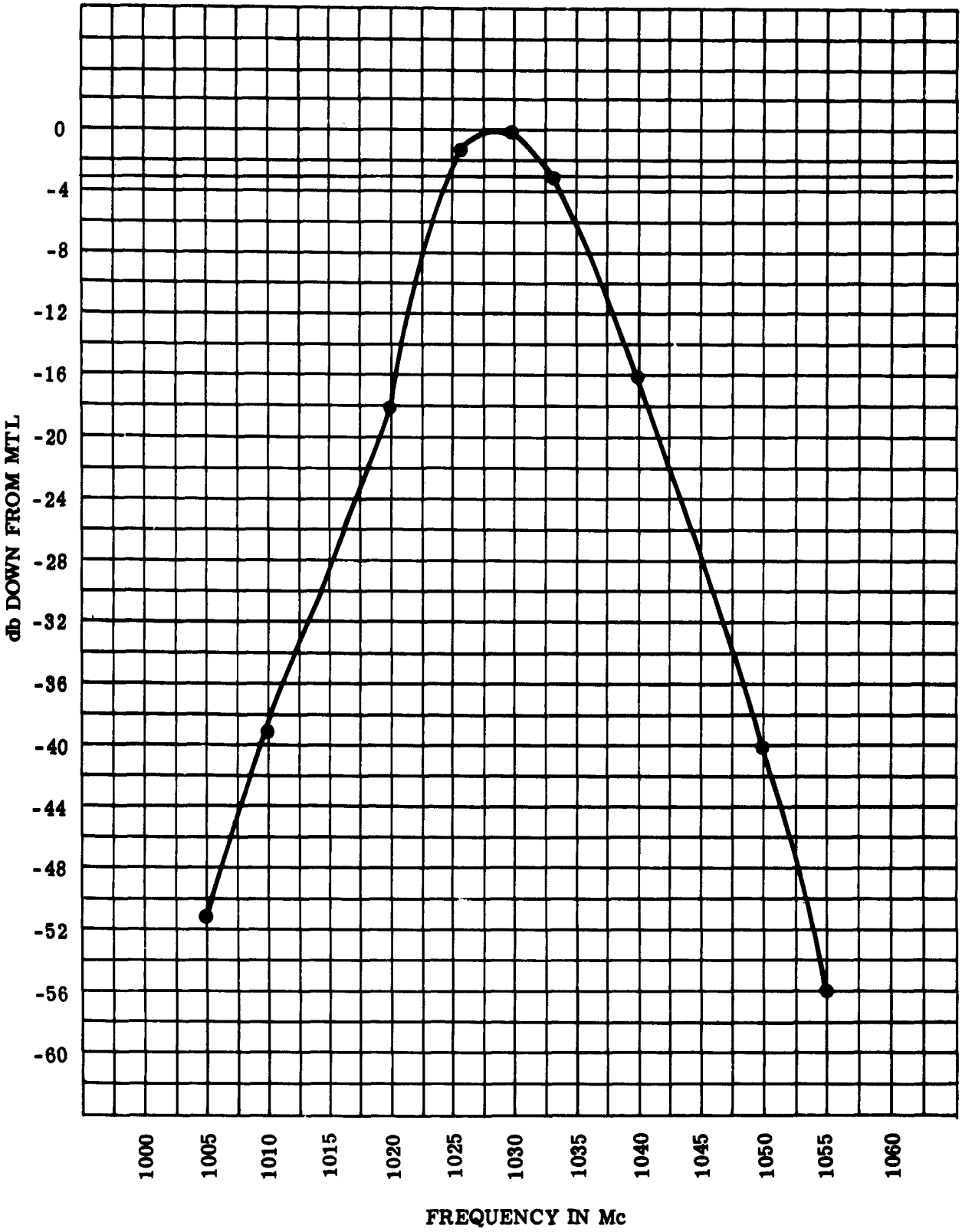
b. -25 dbm Signal

(1) 90% reply from 7.31 to 8.44 usec
(2) 10% reply when less than 7.28 or greater than 8.48 usec

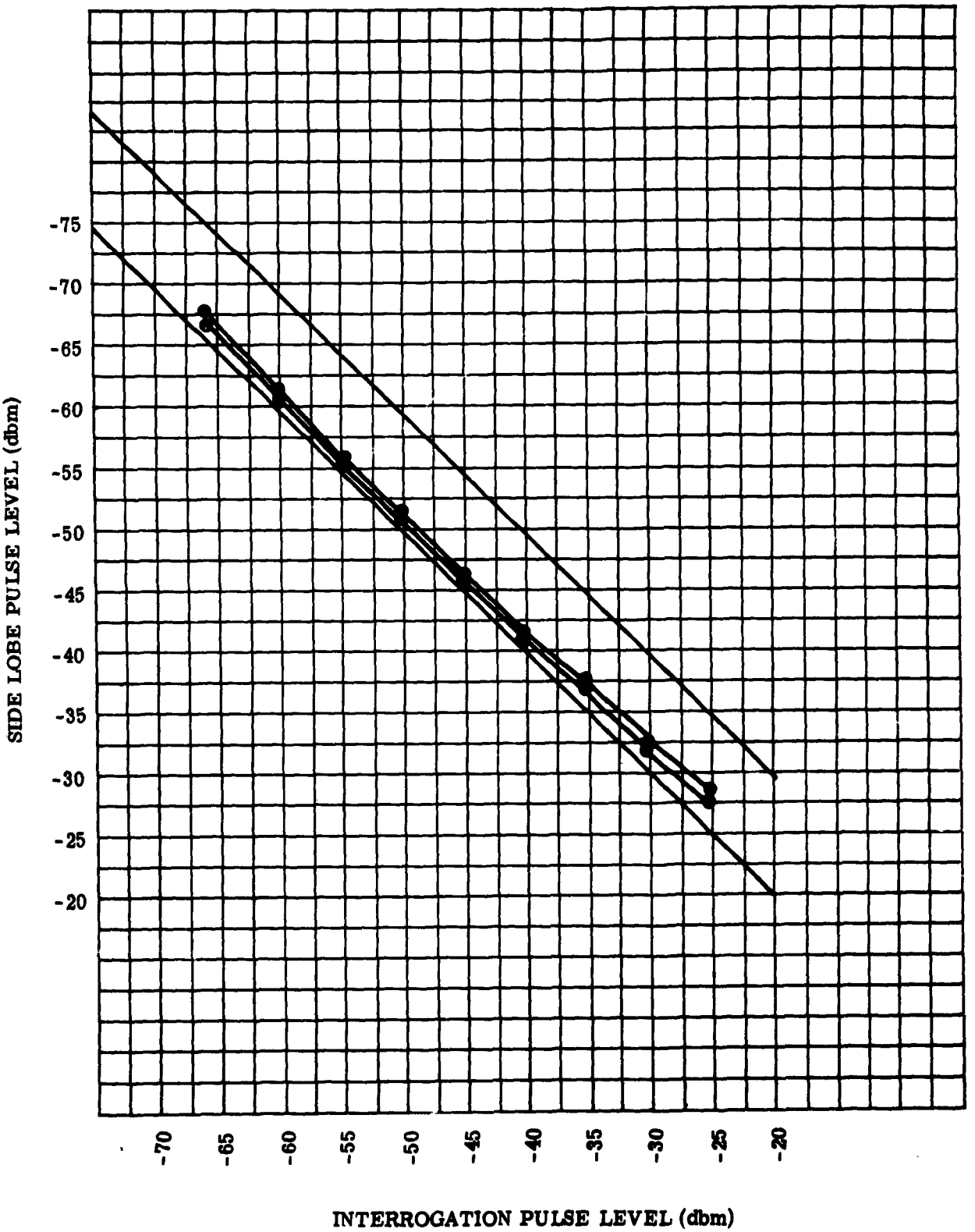
2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second.

DISTANCE FROM F1	TOLERANCE DEVIATION ±.1
A1 usec (2.9)	+.04 usec
A2 usec (5.8)	+.03 usec
A4 usec (8.7)	+.03 usec

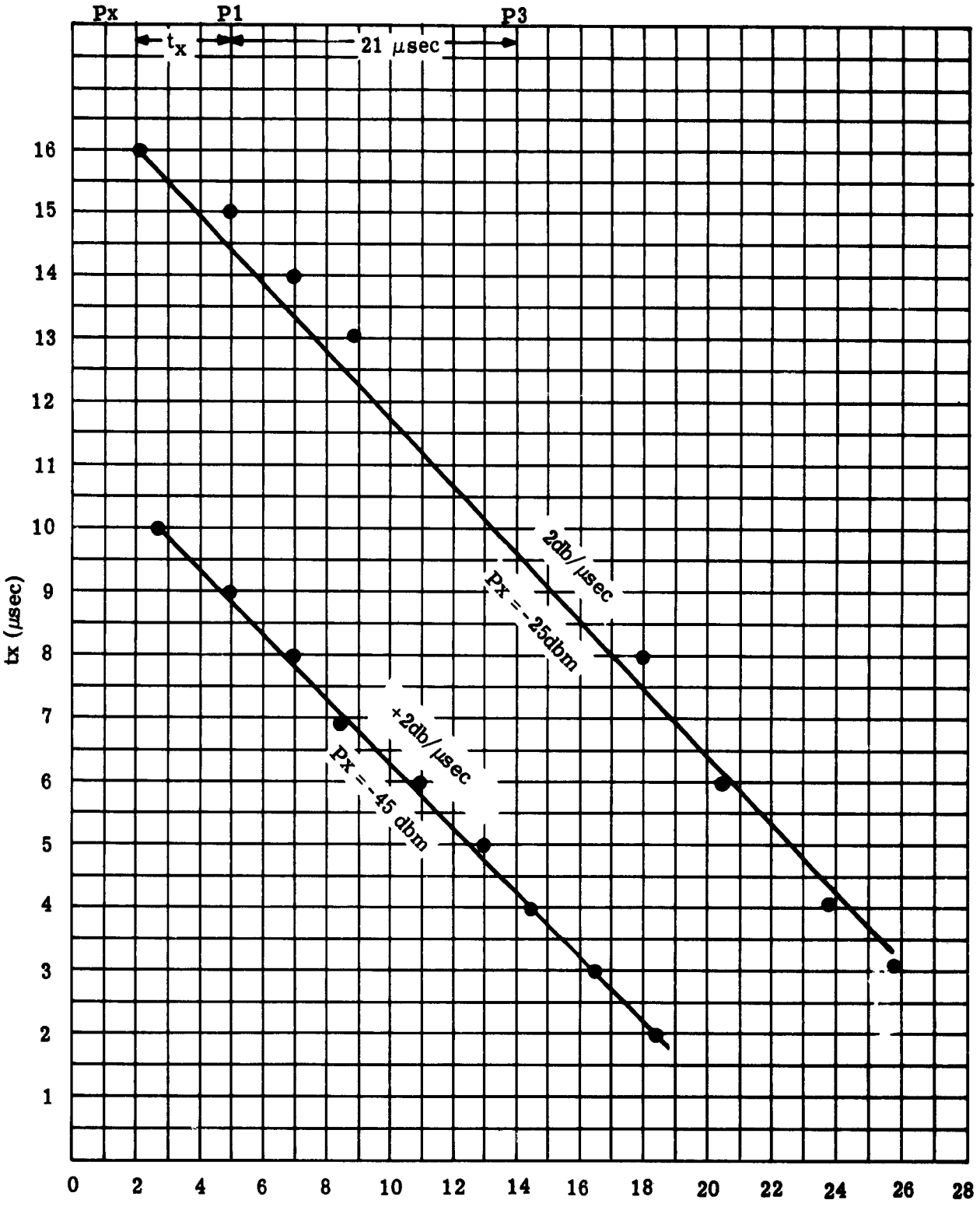
B1	usec (11.6)	+.02 usec
B2	usec (14.5)	+.02 usec
B4	usec (17.4)	+.01 usec
F2	usec (20.3)	0 usec
IDENT	usec (24.65)	-.04 usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 7) II-28



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 8)



ECHO RECOVERY AND PERIOD (GRAPH 9)

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477 TYPE
Serial No. 1
Measured by
Witnessed by
Date

Standard Test Conditions: 20,000 feet altitude

Temperature: 25°C

Primary Power Input Voltage: 13.5 VDC

Humidity: Normal

Vibration: None

Interrogation Signal:

a. Pulse duration:- 0.8 ±.1 usec
b. Pulse rise time:- .05 < t_r < .1 usec
c. Pulse fall time:- .05 < t_f < .2 usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting 64 dbm (-60 to -68 dbm) at 200 prf

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 10)

FREQ (MC)	MTL (-dbm) (90% reply)	▲ db from 1030 MC
1030	-64	0
1034	61	3
1026	60.5	3.5

1020	41.5	22.5
1010	21	43
1005	-9	55
1040	-47	17
1050	-23	41
1055	-3	61

3. Receiver Spurious Responses

   a. Image 61 db down

   b. Other db down at mc

4. Side Lobe Suppression Characteristics (See graph 11)

Interrogation Level P_1	P_3 (-dbm)	SLS Pulse (P_2)-dbm 10% reply	90% reply
64	(MTL)	64+	65
60		61	62
55		56	56.5
50		51	51.5
45		46	46.5
40		40.5	41
35		36	36+
30		32	32.5
25		28.5	29.5
20			
15			

5. Echo Recovery Linearity and Period (See graph 12)

Single Pulse Level - dbm	Single Pulse Spacing, usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	49	15
	3	52	12
	4	54.5	9.5
	5	57	7
	6	60	4
	7	63.5	.5
	8		
	9		
-25	3	38	26
	4	39.5	24.5
	6	43.5	20.5
	8	49	15
	11	56.5	7.5
	13	62	2
	14	64	0
	15		

6. Mode (Decoding Selectivity)

   a. 3 db. above MTL

      (1) 90% Reply from 20.69 to 21.49 usec (21 ±.20 usec)
      (2) 10% Reply when less than 20.66 (20 usec) or greater than 21.53 usec (22 usec)

   b. -25 dbm Signal

      (1) 90% Reply from 20.55 to 21.64 usec
      (2) 10% Reply when less than 20.46 or greater than 21.69 usec

7. Side Lobe Suppression Decoding Selectivity

   a. 3 db above MTL

      (1) 90% Suppression from 1.58 to 2.40 usec (2 ±.15 usec)
      (2) 10% Suppression when less than 1.52 (1 usec) or greater than 2.48 usec (3 usec)

b. -25 dbm Signal

(1) 90% Suppression from 1.35 to 2.70 usec
(2) 10% Suppression when less than 1.31 or greater than 2.80 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (61)	59
10 (54)	51
20 (44)	40
40 (24)	28

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1) MTL Suppression no, Interrogation no
(2) -50 dbm Suppression no, Interrogation no
(3) -25 dbm Suppression no, Interrogation no

9. Side Lobe Suppression Duration and Recovery

a. Suppression Duration 29 usec (< 45 usec)
b. Suppression Recovery usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

a. Amplitude Jitter
(1) 500 replies/sec. > 1%

b. Variation in amplitude between pulses
(1) 500 replies/sec. > 1%

c. Output Power
(1) 100 replies/sec. watts peak
(2) 500 replies/sec. 42.7 watts peak

d. Transmitter Frequency 1089.03 mc

11. Reply Pulse Characteristics

	MAXIMUM	MINIMUM
a. Rise Time	.055 usec	.05 usec (.05 t_r < .1 usec)
b. Decay Time	.19 usec	.18 usec (.05<t_f < .2 usec)
c. Duration	.48 usec	.47 usec (.45 ±.1 usec)

12. Overall Transponder Delay

(7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	3.10 (3 ± .5 usec)
-25 dbm	2.95 (3 ± .5 usec)

13. Transponder Dead Time > 35 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ±.1
A2	usec (5.8)	+.01 usec
A4	usec (8.7)	+.03 usec
B1	usec (11.6)	+.02 usec
B2	usec (14.5)	+.01 usec
B4	usec (17.4)	0 usec
F2	usec (20.3)	0 usec
IDENT	usec (24.65)	

15. Duration of I/P Pulse Transmission

a. Minimum ... sec.

b. Maximum sec.

c. Final Setting 14 sec.

16. Automatic Overload Control (Reference 500 prf input)

a. Sensitivity reduction at 750 prf input

35 db at 670 replies/sec.

b. Sensitivity reduction at 450 prf input

1 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

a. Input Voltage 27.5 V.D.C. amperes

b. Input Voltage 13.5 V.D.C. 1.65 amperes

MODE 3A

1. Mode 3A Decoding Selectivity

a. 3 db above MTL

(1) 90% reply from 7.51 to 8.43 usec (8 ±.2)
(2) 10% reply when less than 7.43 7 usec or greater than 8.47 9 usec.

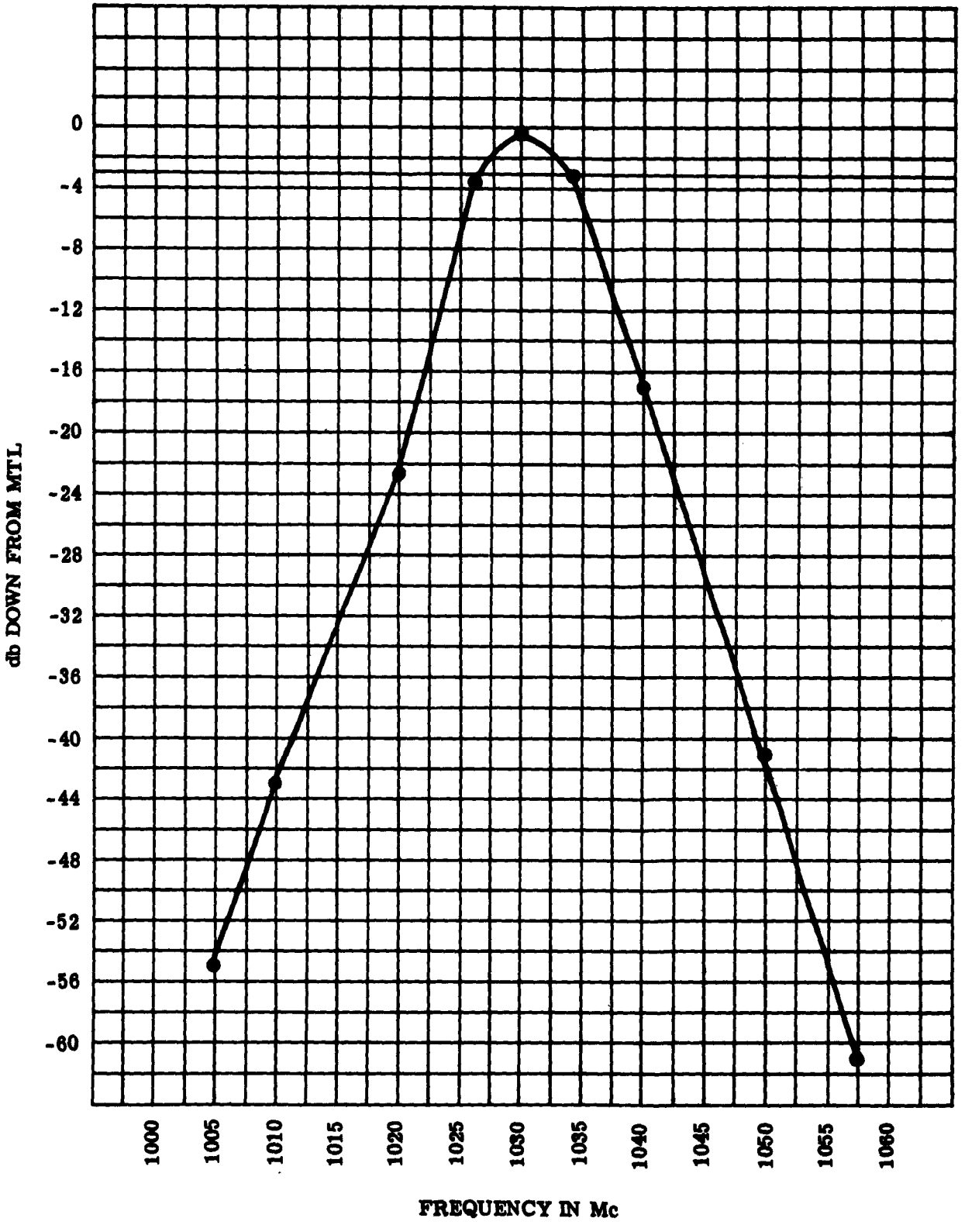
b. -25 dbm Signal

(1) 90% reply from 7.25 to 8.48 usec
(2) 10% reply when less than 7.21 or greater than 8.51 usec

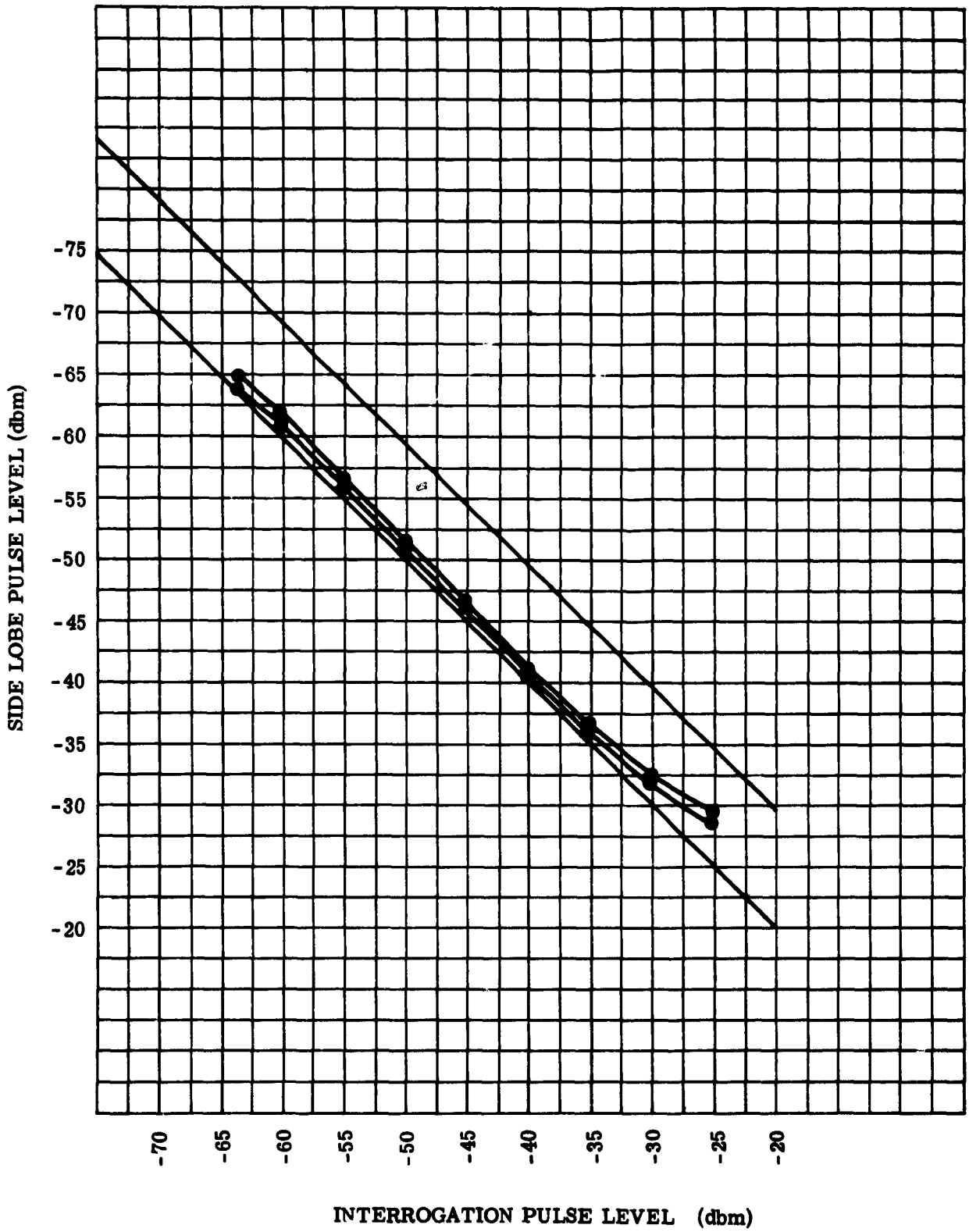
2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

DISTANCE FROM F1		TOLERANCE DEVIATION ±.1
A1	usec (2.9)	+.02 usec
A2	usec (5.8)	+.02 usec
A4	usec (8.7)	+.01 usec
B1	usec (11.6)	0 usec
B2	usec (14.5)	0 usec

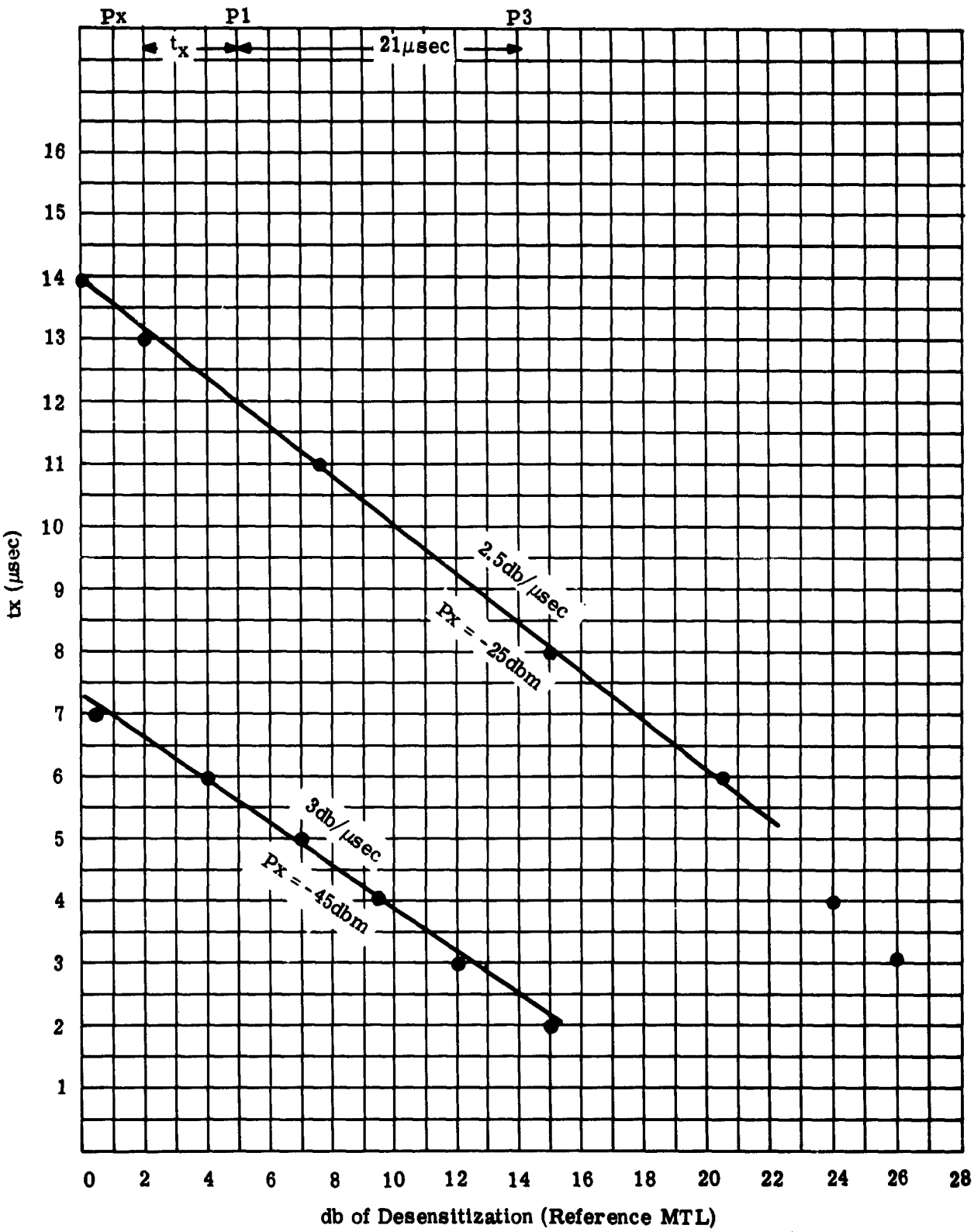
B4	usec (17.4)	-.01 usec
F2	usec (20.3)	-.02 usec
IDENT	usec (24.65)	-.05 usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 10)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 11)



ECHO RECOVERY AND PERIOD (GRAPH 12)

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477
Serial No. 1

TYPE
Measured by
Witnessed by
Date 29 Sept 62

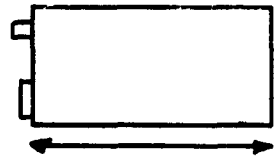
Standard Test Conditions:

Temperature: Room Temperature

Primary Power Input Voltage: 13.5 VDC

Humidity: Normal

Vibration: .020" 10-55 CPS



Interrogation Signal:

a. Pulse duration:- $0.8 \pm .1$ usec
b. Pulse rise time:- $.05 < t_r < .1$ usec
c. Pulse fall time:- $.05 < t_f < .2$ usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting -64 dbm (-60 to -68 dbm) at 200 prf

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See **graph 13**)

FREQ (MC)	MTL (-dbm) (90% reply)	▲ db from 1030 MC
1030	-64	0
1025.88	-61	3
1033.62	-61	3
1050.15	-24	40
1010.07	-24	40
Image	+ 1	-65

3. Receiver Spurious Responses

   a. Image 65 db down

   b. Other ——— db down at ——— mc

4. Side Lobe Suppression Characteristics (See **graph 14**) at 200 prf

Interrogation Level P_1 P_3 (-dbm)	SLS Pulse (P_2) -dbm 10% reply	90% reply
-64 (MTL)	-64+	-65
60	61	61.5
55	56	56.5
50	51	51.5
45	46	46.5
40	41	41.5
35	37.5	38
30	34	34.5
25	30.5	31
20	27.5	28
15		

5. Echo Recovery Linearity and Period (See graph 15 at 200 prf

Single Pulse Level - dbm	Single Pulse Spacing, usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	48	16
	3	50	14
	4	52.5	11.5
	5	54	10
	6	57	7
	7	60	4
	8	62.5	1.5
-25	3	39	25
	4	40.5	23.5
	6	45	19
	8	49	17
	11	56.5	7.5
	13	62	2
	14	63	1

6. Mode (Decoding Selectivity)

   a. 3 db above MTL at 200 prf

      (1) 90% Reply from 20.69 to 21.52 usec(21 ± .20 usec)
      (2) 10% Reply when less than 20.66(20 usec) or greater than 21.57 usec(22 usec)

b. -25 dbm signal

(1) 90% Reply from 20.50 to 21.65 usec
(2) 10% Reply when less than 20.47 or greater than 21.69 usec

7. Side Lobe Suppression Decoding Selectivity

a. 3 db above MTL

(1) 90% Suppression from 1.78 to 2.44 usec($2\pm$ .15 usec)
(2) 10% Suppression when less than 1.60 (1 usec) or greater than 2.48 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.47 to 2.59 usec
(2) 10% Suppression when less than 1.40 or greater than 2.64 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1.

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (61)	-60 dbm
10 (54)	-52 dbm
20 (44)	-42 dbm
40 (24)	-29 dbm

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1)	MTL	Suppression	No	Interrogation	No
(2)	-50 dbm	Suppression	No	Interrogation	No
(3)	-25 dbm	Suppression	No	Interrogation	No

9. Side Lobe Suppression Duration and Recovery

   a. Suppression Duration 30.5 usec (< 45 usec)
   b. Suppression Recovery 1.8 usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

   a. Amplitude Jitter
      (1) 500 replies/sec > 1%

   b. Variation in amplitude between pulses
      (1) 500 replies/sec > 1%

   c. Output Power
      (1) 500 replies/sec 44.2 watts peak

   d. Transmitter Frequency 1089.1 mc

11. Reply Pulse Characteristics

	MAXIMUM	MINIMUM
a. Rise Time	.06 usec	.055 usec (.05 t_r < .1 usec)
b. Decay Time	.19 usec	.18 usec (.05 < t_f < .2 usec)
c. Duration	.46 usec	.45 usec (.45 ± .1 usec)

12. Overall Transponder Delay

(7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	3.05 (3 ± .5 usec)
-25 dbm	2.95 (3 ± .5 usec)

13. Transponder Dead Time > 36 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A2	usec (5.8)	0	usec
A4	usec (8.7)	+ .02	usec
B1	usec (11.6)	+ .01	usec
B2	usec (14.5)	0	usec
B4	usec (17.4)	0	usec
F2	usec (20.3)	- .01	usec
IDENT	usec (24.65)		usec

15. Duration of I/P Pulse Transmission

    a. Minimum sec.

    b. Maximum sec.

    c. Final Setting 19 sec.

16. Automatic Overload Control (Reference 500 prf input)

    a. Sensitivity reduction at 750 prf input
       34 db at 675 replies/sec.

    b. Sensitivity reduction at 450 prf input
       2 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

    a. Input Voltage 27.5 V.D.C. amperes

    b. Input Voltage 13.5 V.D.C. 1.50 amperes

MODE 3A

1. Mode 3A Decoding Selectivity

   a. 3 db above MTL

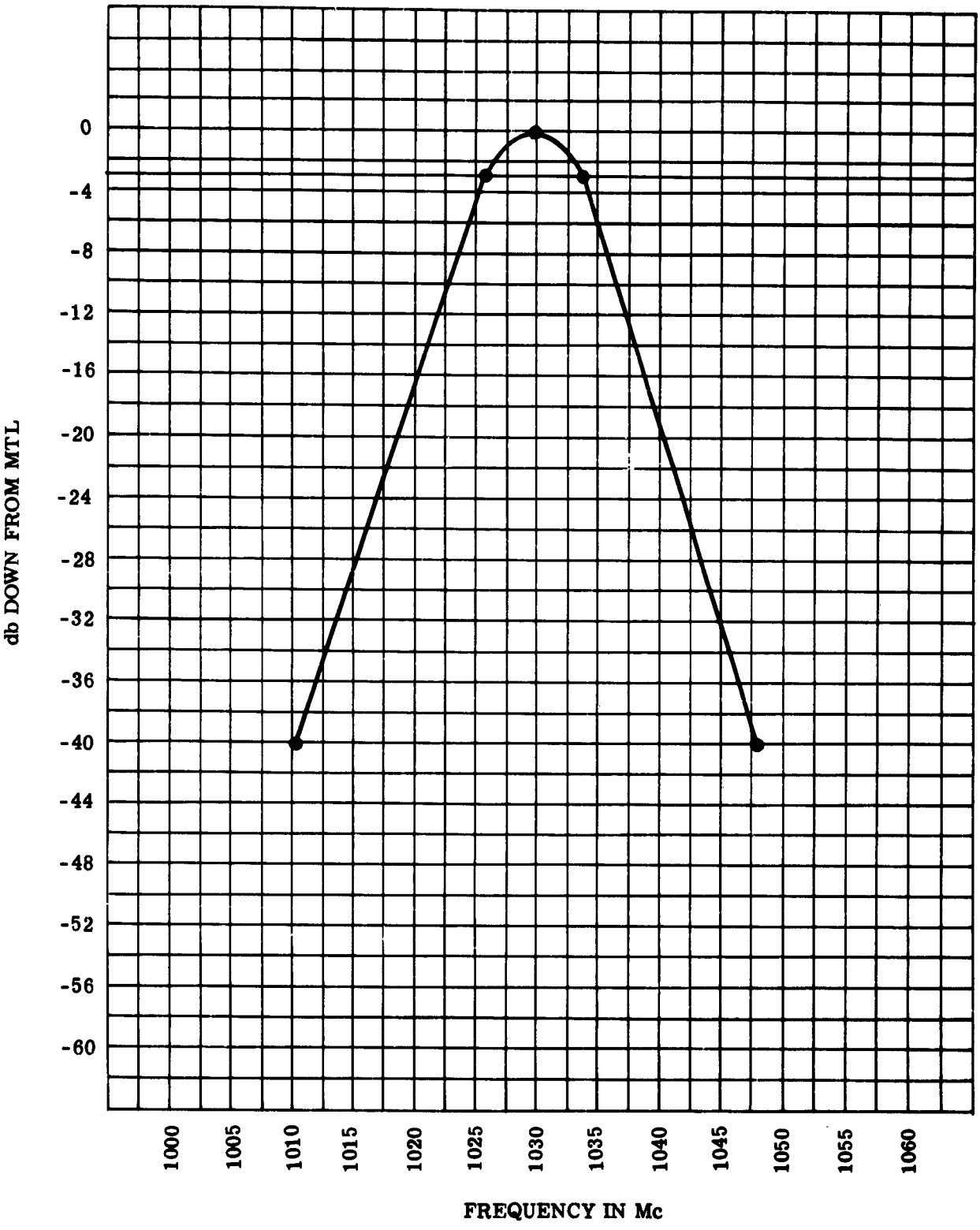
      (1) 90% reply from 7.50 to 8.46 usec (8 ± .2)
      (2) 10% reply when less than 7.46 usec or greater than 8.509 usec.

   b. -25 dbm Signal

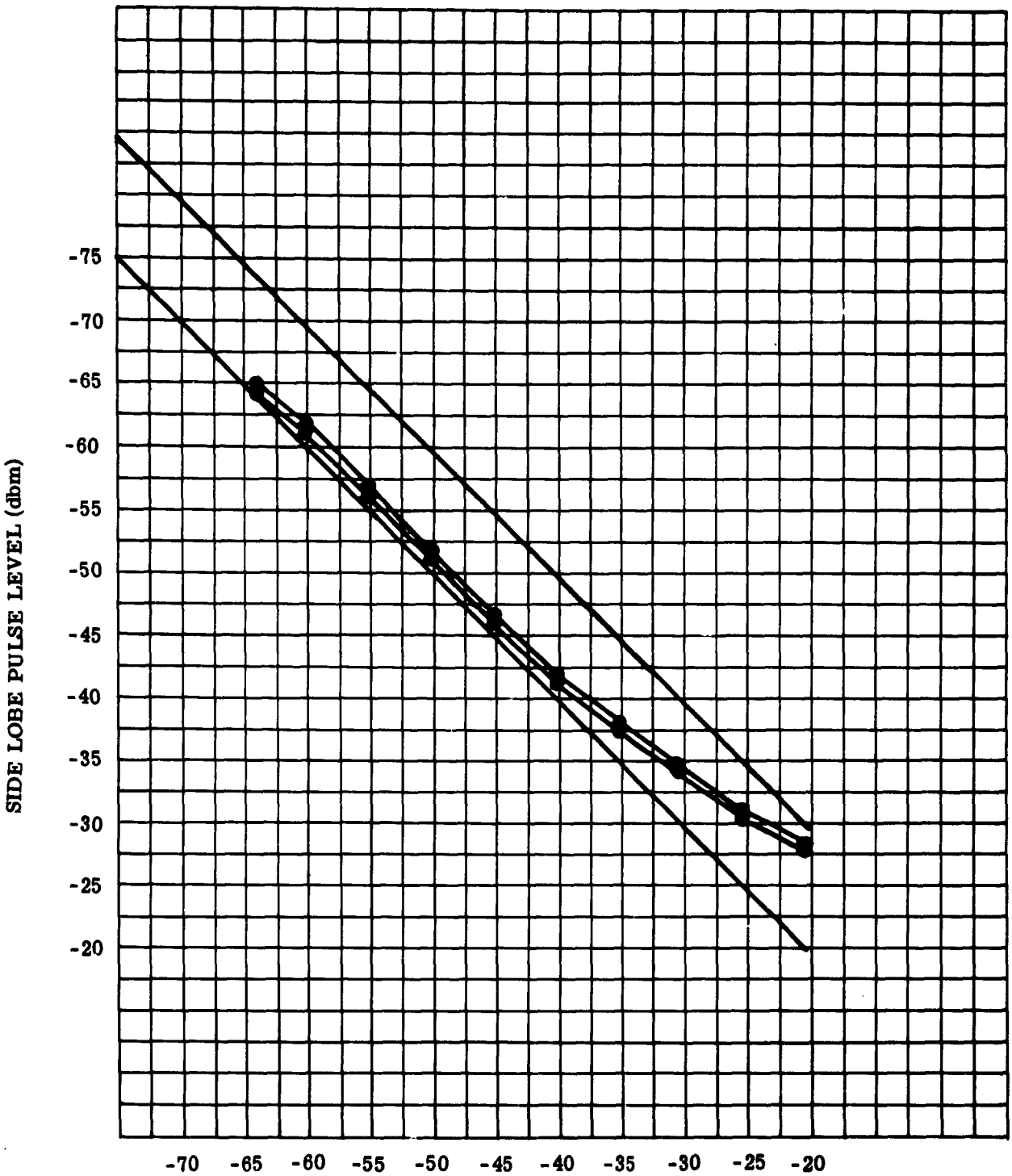
      (1) 90% reply from 7.29 to 8.50 usec
      (2) 10% reply when less than 7.25 or greater than 8.53 usec.

2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

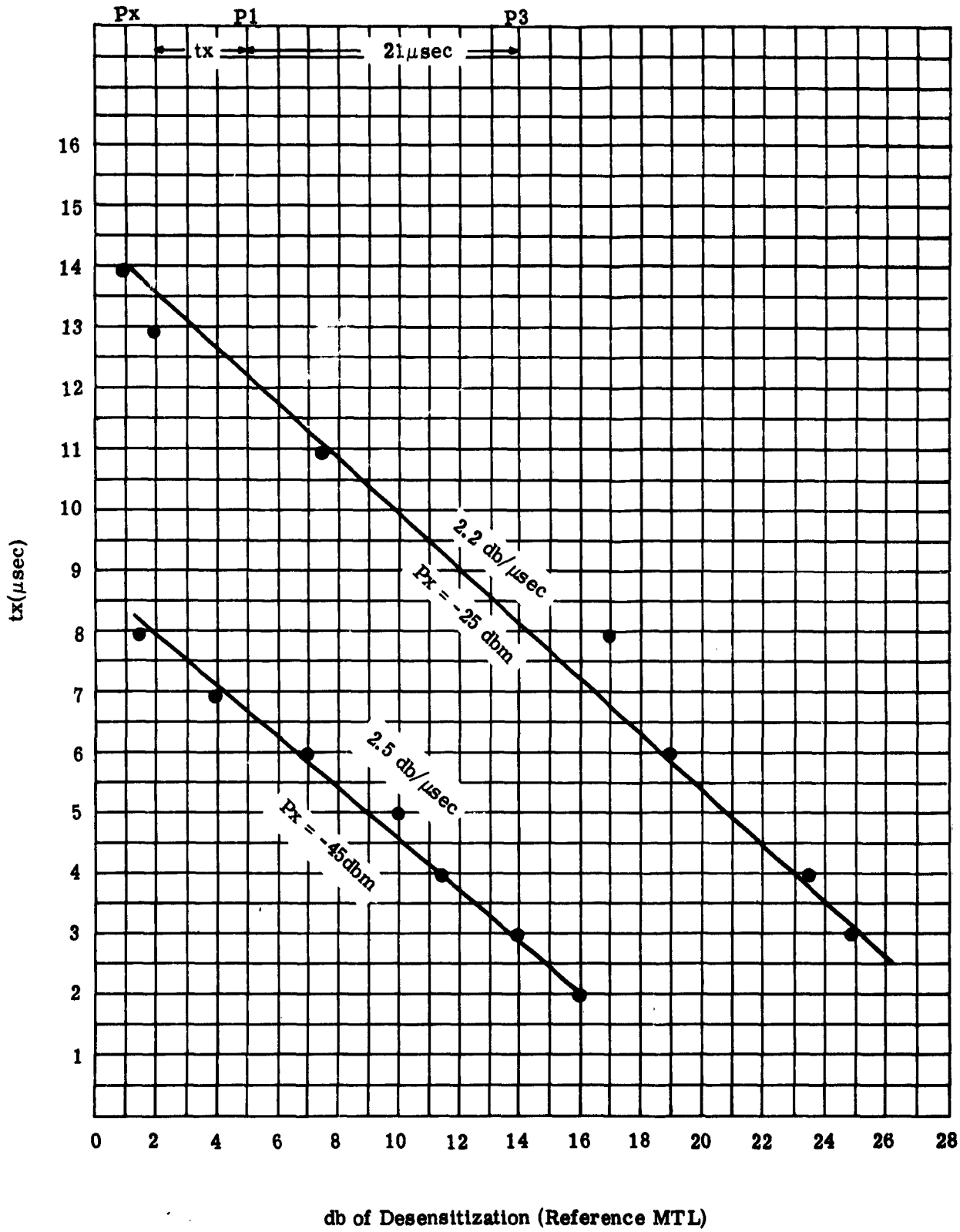
DISTANCE FROM F1		TOLERANCE DEVIATION ± .1
A1	usec (2.9)	+ .02 usec
A2	usec (5.8)	+ .02 usec
A4	usec (8.7)	+ .01 usec
B1	usec (11.6)	0 usec
B2	usec (14.5)	0 usec
B4	usec (17.4)	0 usec
F2	usec (20.3)	- .01 usec
IDENT	usec (24.65)	- .03 usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 13)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 14)



ECHO RECOVERY AND PERIOD (GRAPH 15)

TEST DATA FOR

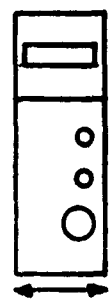
HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477
Serial No. 1

TYPE
Measured by
Witnessed by
Date 1 Oct 62

Standard Test Conditions:



Temperature: Room Temperature

Primary Power Input Voltage: 13.5 VDC

Humidity: Normal

Vibration: .020" 10-55 CPS

Interrogation Signal:

a. Pulse duration:- 0.8 ± .1 usec
b. Pulse rise time:- .05 < t_r < .1 usec
c. Pulse fall time:- .05 < t_f < .2 usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting 65 dbm (-60 to -68 dbm)

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 16)

FREQ (MC)	MTL (-dbm) (90% reply)	△db from 1030 MC
1030	-65	0
1033.47	-62	3
1026.03	-62	3
1010.01	-25	40
1048.68	-25	40
Image	0	

3. Receiver Spurious Responses

   a. Image 65 db down

   b. Other db down at mc

4. Side Lobe Suppression Characteristics (See graph 17)

Interrogation Level P_1 P_3(-dbm)	SLS Pulse (P_2)-dbm 10% reply	90% reply
64 (MTL)	64.5	66
60	61.5	62.5
55	56.5	57
50	51	51.5
45	46	46.5
40	41	41.5
35	37	37.5
30	33.5	34
25	30	30.5
20		
15		

5. Echo Recovery Linearity and Period (See graph 18)

Single Pulse Level - dbm	Single Pulse Spacing, usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	48	17
	3	50.5	14.5
	4	53	12
	5	55	10
	6	57.5	7.5
	7	61	4
	8	64	1
	9		
-25	3	38.5	26.5
	4	40.5	24.5
	6	43	22
	8	48	17
	11	56	10
	13	61.5	3.5
	14	63.5	1.5
	15		

6. Mode (Decoding Selectivity)

a. 3 db above MTL

(1) 90% Reply from 20.72 to 21.57 usec(21 ± .20 usec)
(2) 10% Reply when less than 20.67(20 usec) or greater than 21.60 usec (22 usec)

b. -25 dbm signal

(1) 90% Reply from 20.48 to 21.65 usec
(2) 10% Reply when less than 20.41 or greater than 21.70 usec

7. Side Lobe Suppression Decoding Selectivity

a. 3 db above MTL

(1) 90% Suppression from 1.69 to 2.44 usec (2 ± .15 usec)
(2) 10% Suppression when less than 1.60 (1 usec) or greater than 2.48 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.52 to 2.65 usec
(2) 10% Suppression when less than 1.42 or greater than 2.70 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (61)	-58 dbm
10 (54)	-51 dbm
20 (44)	-41 dbm
40 (24)	-30 dbm

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1)	MTL	Suppression	No	Interrogation	No
(2)	-50 dbm	Suppression	No	Interrogation	No
(3)	-25 dbm	Suppression	No	Interrogation	No

9. Side Lobe Suppression Duration and Recovery

   a. Suppression Duration 31.5 usec (< 45 usec)
   b. Suppression Recovery 1.85 usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

   a. Amplitude Jitter
      (1) 500 replies/sec > 1%

   b. Variation in amplitude between pulses
      (1) 500 replies/sec > 1%

   c. Output Power
      (1) 100 replies/sec watts peak
      (2) 500 replies/sec 40.7 watts peak

   d. Transmitter Frequency 1089.3 mc

11. Reply Pulse Characteristics

		MAXIMUM	MINIMUM
a.	Rise Time	.06 usec	.05 usec (.05 t_r < .1 usec)
b.	Decay Time	.19 usec	.18 usec (.05 < t_f < .2usec)
c.	Duration	.46 usec	.46 usec (.45 $\pm$ .1 usec)

12. Overall Transponder Delay

(7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	3.05 (3 $\pm$ .5 usec)
-25 dbm	2.90 (3 $\pm$ .5 usec)

13. Transponder Dead Time > 36 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A2	usec (5.8)	0	usec
A4	usec (8.7)	0	usec
B1	usec (11.6)	- .01	usec
B2	usec (14.5)	- .01	usec
B4	usec (17.4)	- .02	usec
F2	usec (20.3)	- .03	usec
IDENT	usec (24.65)		usec

15. Duration of I/P Pulse Transmission

a. Minimum sec.

b. Maximum sec.

c. Final Setting 15 sec.

16. Automatic Overload Control (Reference 500 prf input)

a. Sensitivity reduction at 750 prf input
32 db at 650 replies/sec.

b. Sensitivity reduction at 450 prf input
2 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

a. Input Voltage 27.5 V.D.C. amperes

b. Input Voltage 13.5 V.D.C. 1.45 amperes

MODE 3A

1. Mode 3A Decoding Selectivity

   a. 3 db above MTL

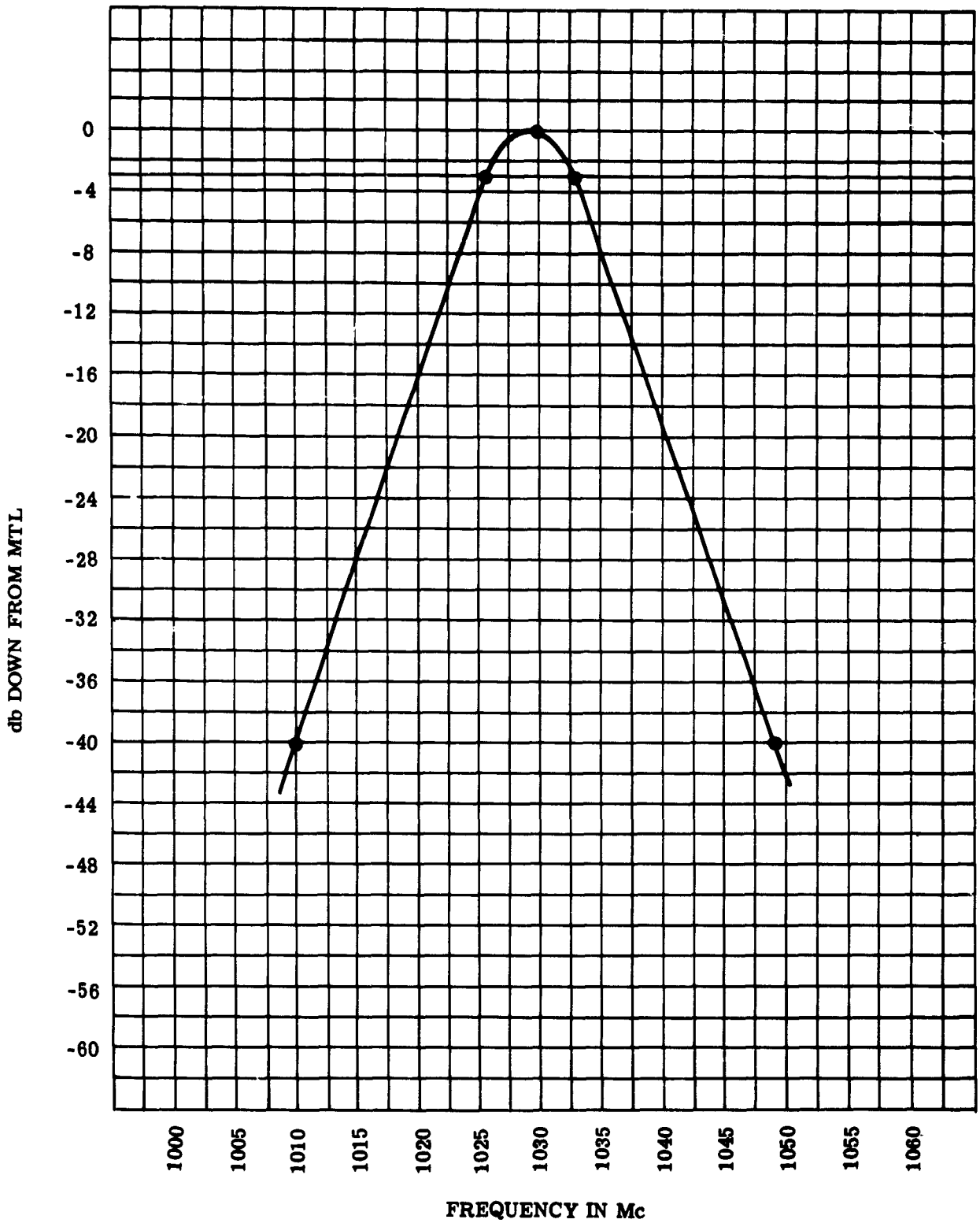
      (1) 90% reply from 7.45 to 8.42 usec (8 ± .2)
      (2) 10% reply when less than 7.41 7 usec or greater than 8.45 9 usec.

   b. -25 dbm Signal

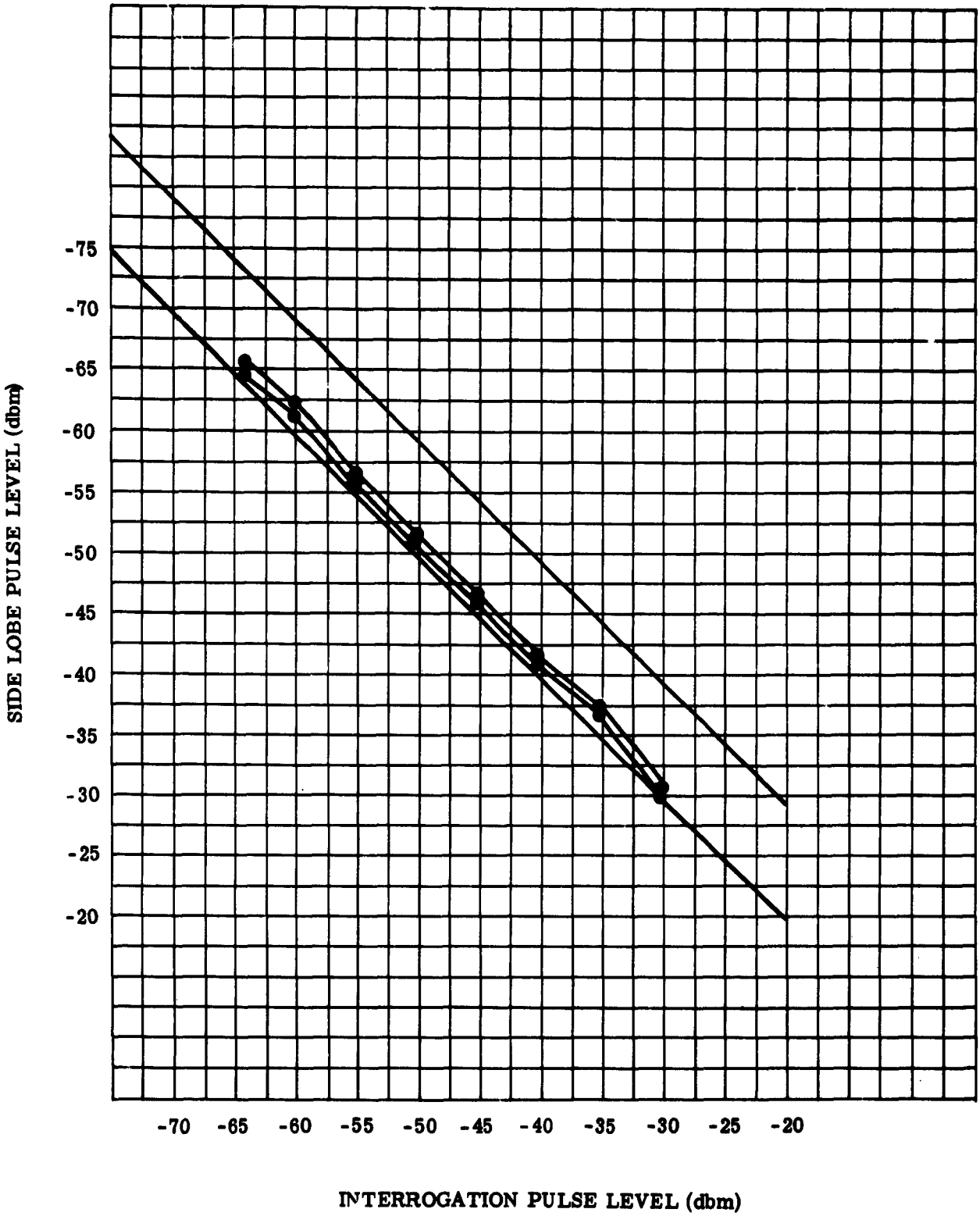
      (1) 90% reply from 7.36 to 8.47 usec
      (2) 10% reply when less than 7.33 or greater than 8.51 usec.

2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

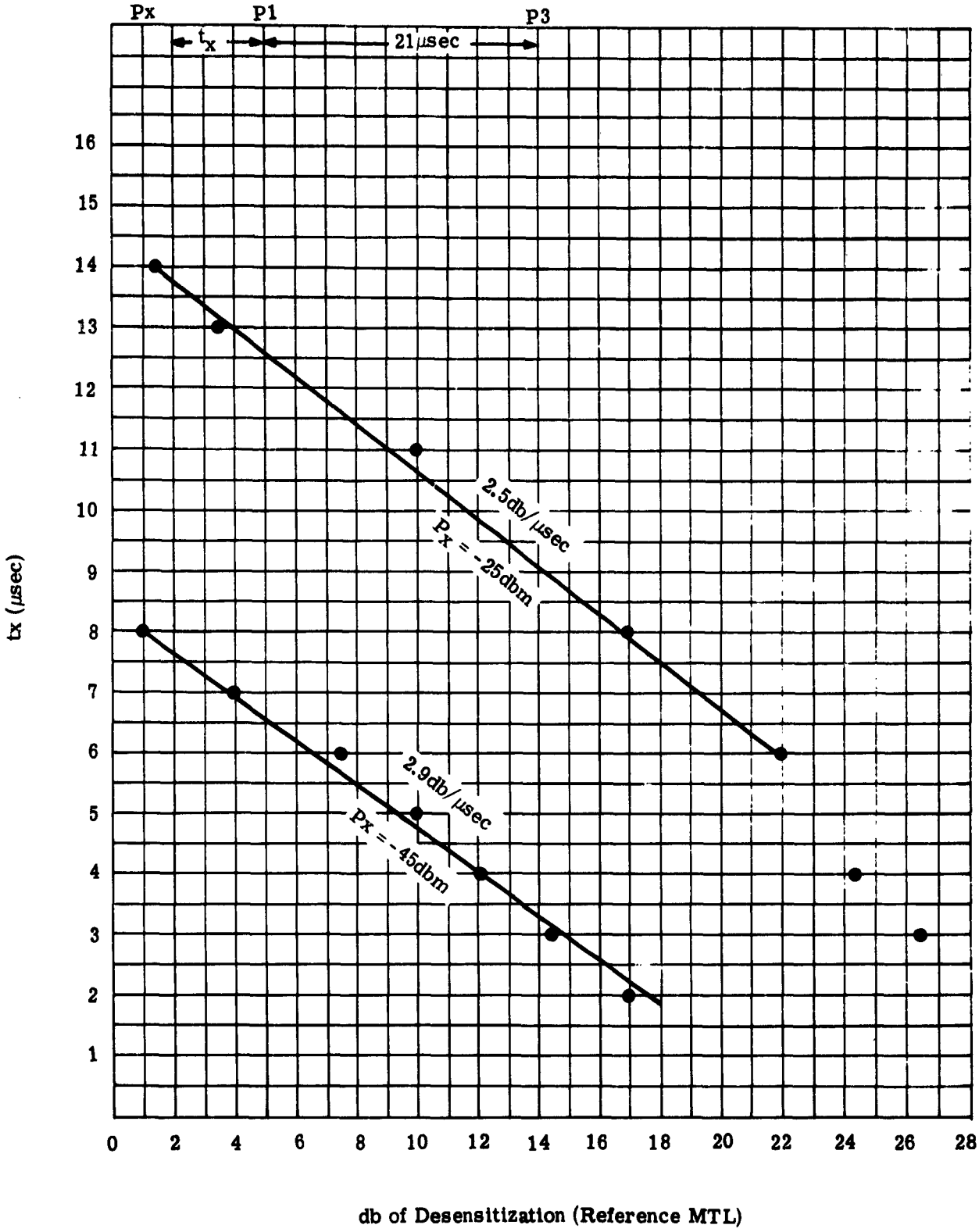
DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A1	usec (2.9)	+ .02	usec
A2	usec (5.8)	+ .01	usec
A4	usec (8.7)	+ .01	usec
B1	usec (11.6)	0	usec
B2	usec (14.5)	0	usec
B4	usec (17.4)	0	usec
F2	usec (20.3)	- .01	usec
IDENT	usec (24.65)	- .03	usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 16)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 17)



ECHO RECOVERY AND PERIOD (GRAPH 18)

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477
Serial No. 1

TYPE
Measured by
Witnessed by
Date 1 Oct 62

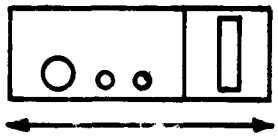
Standard Test Condition:

Temperature: Room Temperature

Primary Power Input Voltage: 13.5 VDC

Humidity: Normal

Vibration: .020" 10-55 CPS



Interrogation Signal:

a. Pulse duration:- $0.8 \pm .1$ usec
b. Pulse rise time:- $.05 < t_r < .1$ usec
c. Pulse fall time:- $.05 < t_f < .2$ usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting -65 dbm (-60 to -68 dbm)

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 19)

FREQ (MC)	MTL (-dbm) (90% reply)	▲ db from 1030 MC
1030	-65	0
1033.29	-62	3
1026.45	-62	3
1010.07	-25	40
1051.77	-25	40
Image	+1	66

3. Receiver Spurious Responses

   a. Image 66 db down

   b. Other ——— db down at —— mc

4. Side Lobe Suppression Characteristics (See **graph 20**)

Interrogation Level P_1 P_3(-dbm)	SLS Pulse (P_2)-dbm 10% reply	90% reply
65 (MTL)	65	66
60	61	62
55	56	56.5
50	51	51+
45	46	46.5
40	41	41.5
35	37	37.5
30	33	33.5
25	29.5	30
20		
15		

5. Echo Recovery Linearity and Period (See graph 21)

Single Pulse Level - dbm	Single Pulse Spacing , usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	48	17
	3	50.5	14.5
	4	53	12
	5	55	10
	6	57.5	7.5
	7	60.5	4.5
	8	63.5	1.5
	9		
-25	3	38.5	26.5
	4	40.5	24.5
	6	44	21
	8	48.5	16.5
	11	55	10
	13	61	4
	14	63	2
	15		

6. Mode (Decoding Selectivity)

a. 3 db above MTL

(1) 90% Reply from 20.71 to 21.59 usec(21 ± .20 usec)
(2) 10% Reply when less than 20.68 (20 usec) or greater than 21.61 usec (22 usec)

b. -25 dbm signal

(1) 90% Reply from 20.52 to 21.66 usec
(2) 10% Reply when less than 20.41 or greater than 21.70 usec

7. Side Lobe Suppression Decoding Selectivity

a. 3 db above MTL

(1) 90% Suppression from 1.71 to 2.44 usec (2 ± .15 usec)
(2) 10% Suppression when less than 1.60 (1 usec) or greater than 2.50 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.49 to 2.68 usec
(2) 10% Suppression when less than 1.40 or greater than 2.74 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1.

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (62)	-60 dbm
10 (55)	-53 dbm
20 (45)	-42 dbm
40 (25)	-30 dbm

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1)	MTL	Suppression	No	Interrogation	No
(2)	-50 dbm	Suppression	No	Interrogation	No
(3)	-25 dbm	Suppression	No	Interrogation	No

9. Side Lobe Suppression Duration and Recovery

a. Suppression Duration 31.5 usec (< 45 usec)
b. Suppression Recovery 1.85 usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

    a. Amplitude Jitter
       (1) 500 replies/sec > 1%

    b. Variation in amplitude between pulses
       (1) 500 replies/sec > 1%

    c. Output Power
       (1) 100 replies/sec watts peak
       (2) 500 replies/sec 41.5 watts peak

    d. Transmitter Frequency 1089.24 mc

11. Reply Pulse Characteristics

	MAXIMUM	MINIMUM
a.	Rise Time .06 usec	.05 usec (.05 t_r < .1 usec)
b.	Decay Time .19 usec	.18 usec (.05 < t_f < .2 usec
c.	Duration .47 usec	.47 usec (.45 ± .1 usec)

12. Overall Transponder Delay

    (7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	3.05 (3 ± .5 usec)
-25 dbm	2.95 (3 ± .5 usec)

13. Transponder Dead Time > 36 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A2	usec (5.8)	0	usec
A4	usec (8.7)	0	usec
B1	usec (11.6)	- .01	usec
B2	usec (14.5)	- .02	usec
B4	usec (17.4)	- .02	usec
F2	usec (20.3)	- .03	usec
IDENT	usec (24.65)		usec

15. Duration of I/P Pulse Transmission

    a. Minimum sec.

    b. Maximum sec.

    c. Final Setting 15 sec.

16. Automatic Overload Control (Reference 500 prf input)

    a. Sensitivity reduction at 750 prf input
    32 db at 65 replies/sec.

    b. Sensitivity reduction at 450 prf input
    2 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

    a. Input Voltage 27.5 V.D.C. amperes

    b. Input Voltage 13.5 V.D.C. 1.45 amperes

MODE 3A

1. Mode 3A Decoding Selectivity

   a. 3 db above MTL

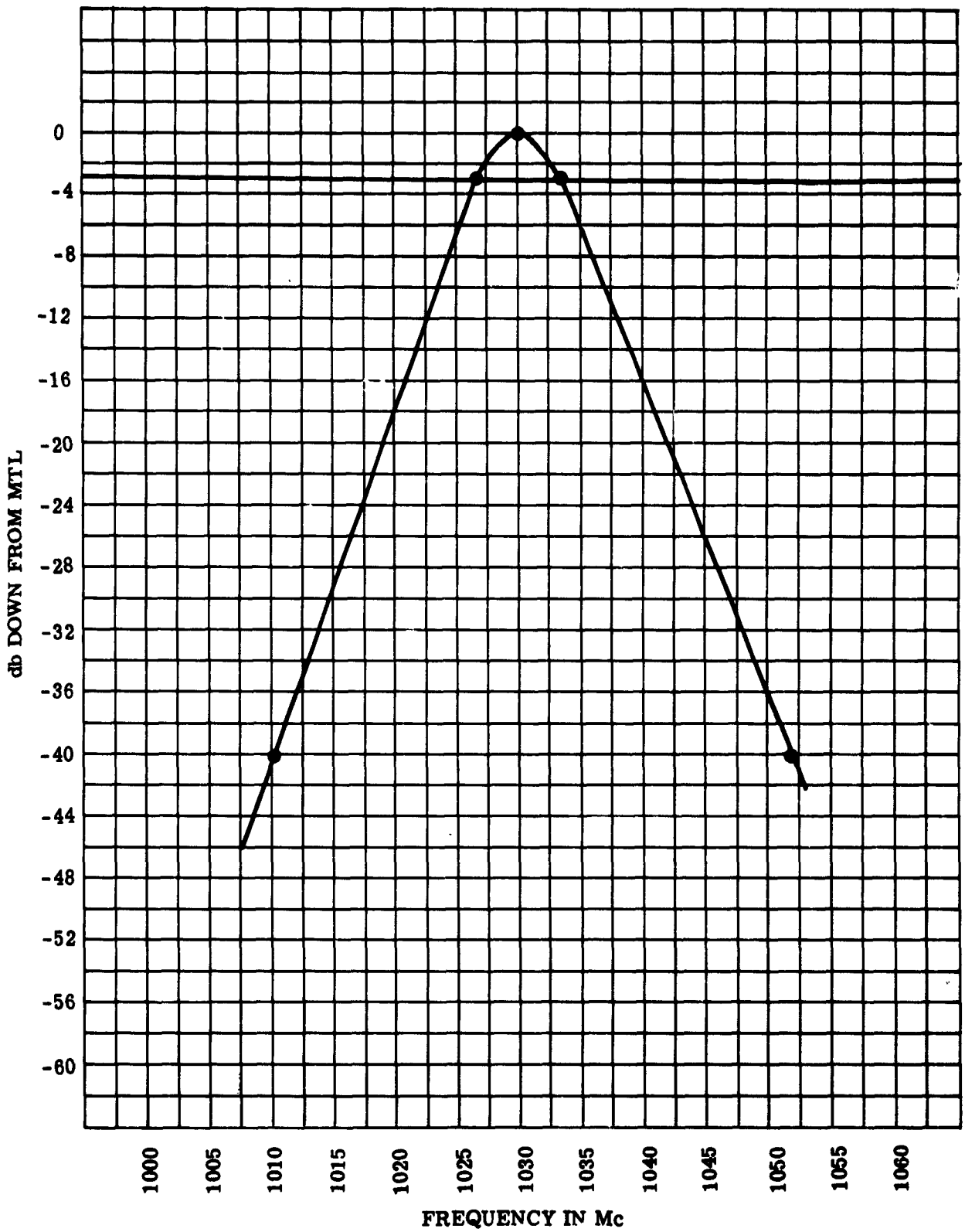
      (1) 90% reply from 7.57 to 8.44 usec (8 ± .2)
      (2) 10% reply when less than 7.50 7 usec or greater than 8.48 9 usec.

   b. -25 dbm Signal

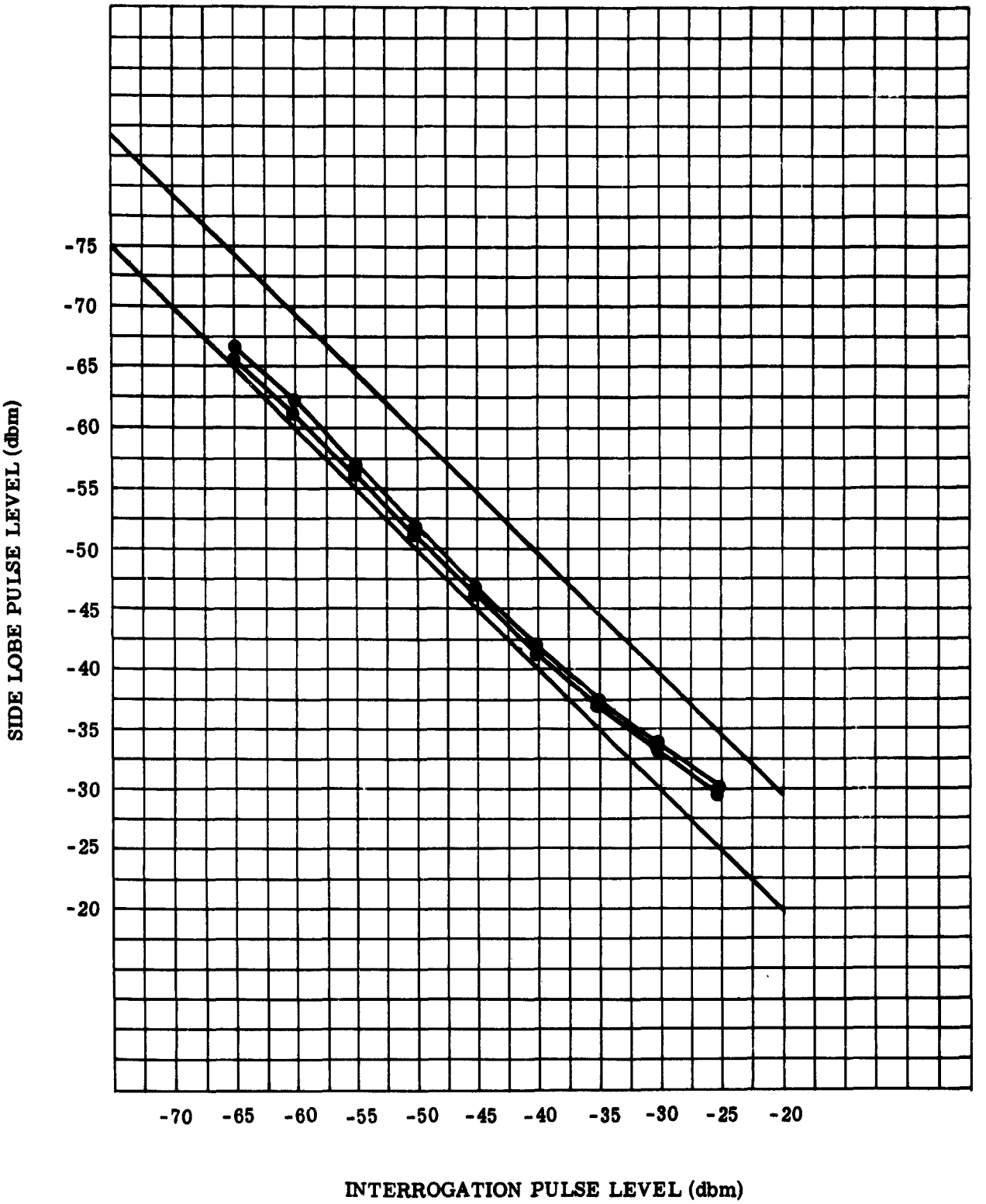
      (1) 90% reply from 7.27 to 8.48 usec
      (2) 10% reply when less than 7.24 or greater than 8.53 usec.

2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

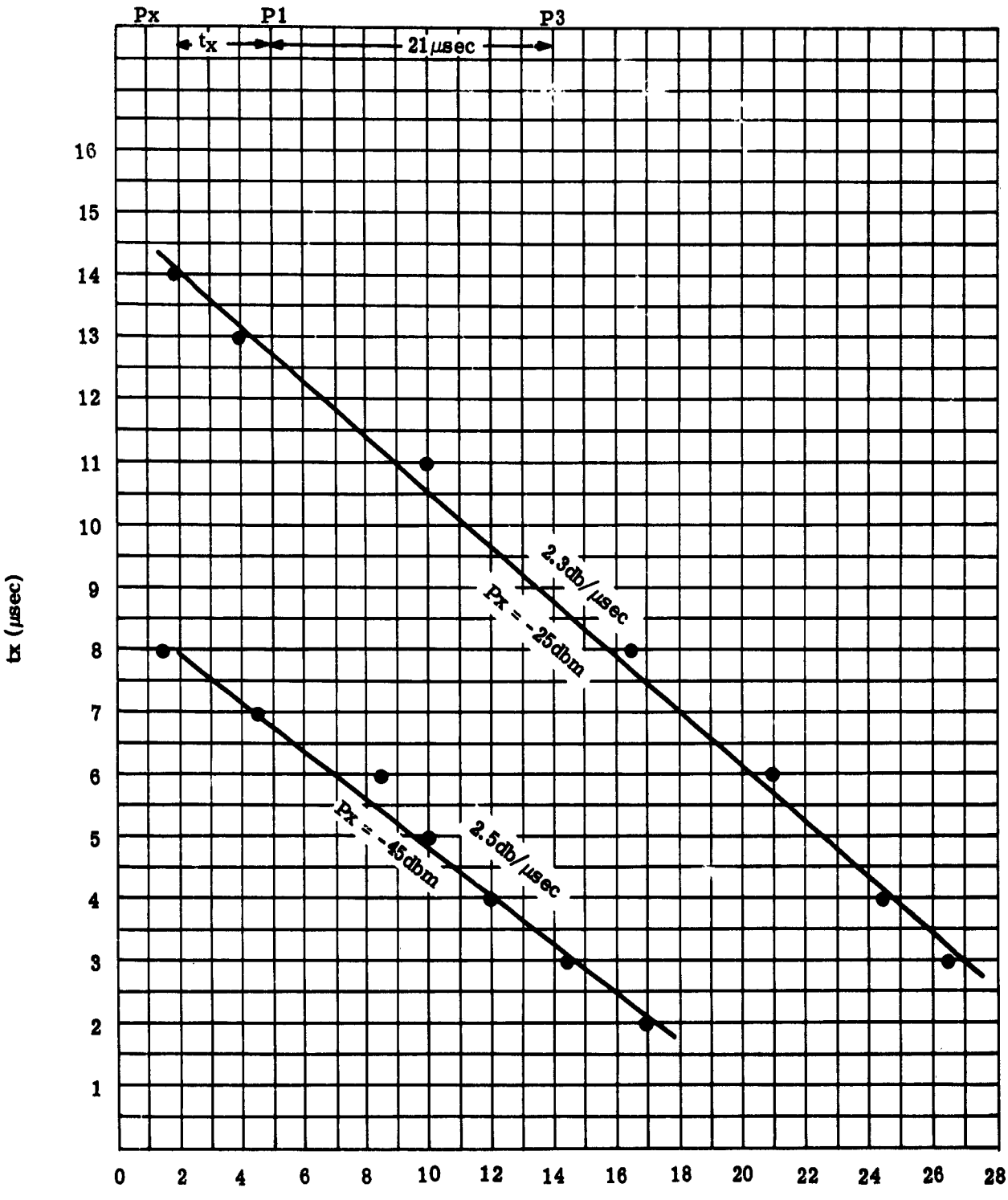
DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A1	usec (2.9)	+ .02	usec
A2	usec (5.8)	+ .01	usec
A4	usec (8.7)	0	usec
B1	usec (11.6)	0	usec
B2	usec (14.5)	0	usec
B4	usec (17.4)	- .01	usec
F2	usec (20.3)	- .02	usec
IDENT	usec (24.65)	- .03	usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 19)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 20)



ECHO RECOVERY AND PERIOD (GRAPH 21)

TEST DATA FOR

HAZELTINE TECHNICAL DEVELOPMENT CENTER, INC.

SLATE II

FAA Contract - FAA/ARDS-477
Serial No. 1

TYPE
Measured by
Witnessed by
Date 7 Oct 62

Standard Test Conditions: AFTER SHOCK TEST

Temperature: Room Temperature

Primary Power Input Voltage: 13.5 VDC

Humidity: Normal

Vibration: None

Interrogation Signal:

a. Pulse duration:- 0.8 ± .1 usec
b. Pulse rise time:- .05 < t_r < .1 usec
c. Pulse fall time:- .05 < t_f < .2 usec

1. Triggering Sensitivity (90% reply efficiency)

a. Sensitivity adjustment range

(1) Minimum dbm
(2) Maximum dbm
(3) Final Setting -64 dbm (-60 to -68 dbm) at 200 prf

b. Squitter Rate 0 replies/sec.

2. Receiver Selectivity (See graph 22)

FREQ (MC)	MTL (-dbm) (90% reply)	▲ db from 1030 MC
1030	-64	0
1033.83	-61	3
1025.01	-61	3
1008.75	-24	40
1051.71	-24	40
Image	> +4	> 68

3. Receiver Spurious Responses

   a. Image 68 db down

   b. Other db down at mc

4. Side Lobe Suppression Characteristics (See graph 23)

Interrogation Level P_1	P_3(-dbm)	SLS pulse (P_2)-dbm 10% reply	90% reply
64	(MTL)	64+	65
60		60.5	61
55		55.5	56
50		50.5	51
45		45.5	46
40		41	41+
35		36.5	37
30		33	33.5
25		29.5	30
20			
15			

5. Echo Recovery Linearity and Period (See graph 24)

Single Pulse Level - dbm	Single Pulse Spacing, usec preceding first interrogation pulse	Interrogation signal level -dbm for 90% triggering	db of desensitization
-45	2	48	16
	3	50	14
	4	52	12
	5	54	10
	6	57	7
	7	59	5
	8	61.5	2.5
	9	64	0
-25	3	39.5	24.5
	4	41	23
	6	44.5	19.5
	8	48	16
	11	55	9
	13	59	5
	14	62.5	1.5
	15		

6. Mode (Decoding Selectivity)

a. 3 db above MTL

(1) 90% Reply from 20.65 to 21.55 usec(21 $\pm$ .20 usec)
(2) 10% Reply when less than 20.61(20 usec) or greater than 21.60 usec (22 usec)

b. -25 dbm signal

(1) 90% Reply from 20.55 to 21.63 usec
(2) 10% Reply when less than 20.49 or greater than 21.68 usec

7. Side Lobe Suppression Decoding Selecitivity

a. 3 db above MTL

(1) 90% Suppression from 1.78 to 2.39 usec (2 ± .15 usec)
(2) 10% Suppression when less than 1.58 (1 usec) or greater than 2.44 usec (3 usec)

b. -25 dbm signal

(1) 90% Suppression from 1.62 to 2.54 usec
(2) 10% Suppression when less than 1.54 or greater than 2.63 usec

8. Wide Pulse Desensitization and Discrimination

a. Desensitization (10 usec echo with leading edge spaced 16 us from P_1.

Interrogation Signal db above MTL	Echo signal level for 50% replies
3 (61)	-60 dbm
10 (54)	-53 dbm
20 (44)	-44 dbm
40 (24)	-29.5 dbm

b. Pulse Width Discrimination

8.0 usec RF Pulse Width (Single Pulse)

(1)	MTL	Suppression	No	Interrogation	No
(2)	-50 dbm	Suppression	No	Interrogation	No
(3)	-25 dbm	Suppression	No	Interrogation	No

9. Side Lobe Suppression Duration and Recovery

a. Suppression Duration 31.5 usec (< 45 usec)
b. Suppression Recovery usec (< 2 usec)

10. Transmitter Power Output Variation (4 pulse reply train)

    a. Amplitude Jitter
       (1) 500 replies/sec > 1%

    b. Variation in amplitude between pulses
       (1) 500 replies/sec > 1%

    c. Output Power
       (1) 100 replies/sec watts peak
       (2) 500 replies/sec 46.3 watts peak

    d. Transmitter Frequency 1090 mc

11. Reply Pulse Characteristics

		MAXIMUM	MINIMUM
a.	Rise Time	.055 usec	.05 usec (.05 t_r < .1 usec)
b.	Decay Time	.17 usec	.16 usec (.05 < t_f < .2 usec)
c.	Duration	.54 usec	.54 usec (.45 ± .1 usec)

12. Overall Transponder Delay

    (7 pulse reply trains at 500 replies per second)

INPUT LEVEL	DELAY
-60 dbm	2.95 (3 ± .5 usec)
-25 dbm	2.82 (3 ± .5 usec)

13. Transponder Dead Time > 36 usec (less than 75 usec)

14. Transmitter Pulse Spacing with Reference to F1 (500 replies per second)

DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A2	usec (5.8)	+ .02	usec
A4	usec (8.7)	+ .02	usec
B1	usec (11.6)	+ .01	usec
B2	usec (14.5)	0	usec
B4	usec (17.4)	0	usec
F2	usec (20.3)	- .01	usec
IDENT	usec (24.65)		usec

15. Duration of I/P Pulse Transmission

    a. Minimum sec.

    b. Maximum sec.

    c. Final Setting 15 sec.

16. Automatic Overload Control (Reference 500 prf input)

    a. Sensitivity reduction at 700 prf input
       30 db at 630 replies/sec.

    b. Sensitivity reduction at 450 prf input
       2 db at 405 replies/sec.

17. Power Consumption (7 pulse reply train at 500 prf)

    a. Input Voltage 27.5 V.D.C. amperes

    b. Input Voltage 13.5 V.D.C. 1.50 amperes.

MODE 3A

1. Mode 3A Decoding Selectivity

   a. 3 db above MTL

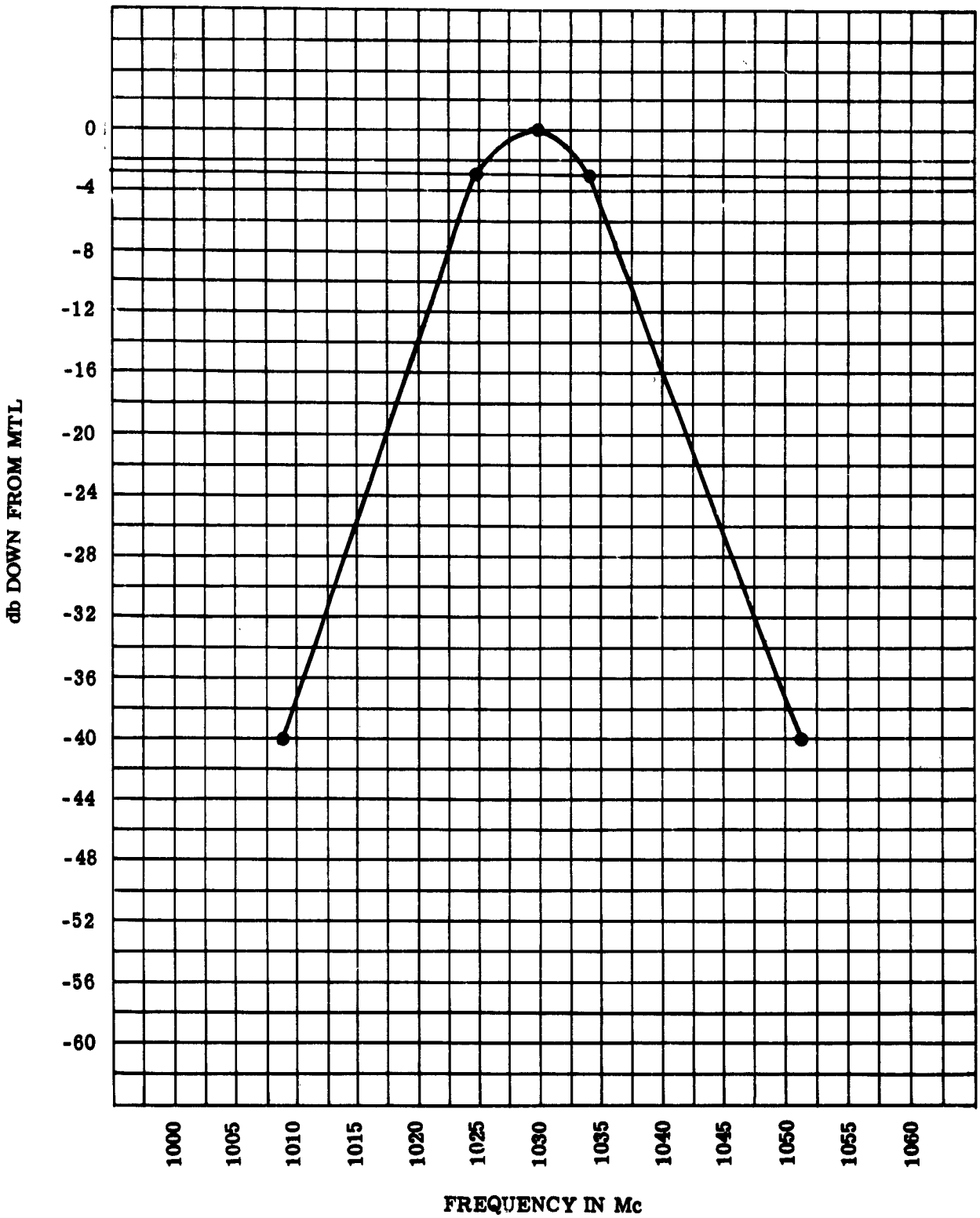
      (1) 90% reply from 7.47 to 8.47 usec (8 ± .2)
      (2) 10% reply when less than 7.44 7 usec or greater than 8.50 9 usec.

   b. -25 dbm Signal

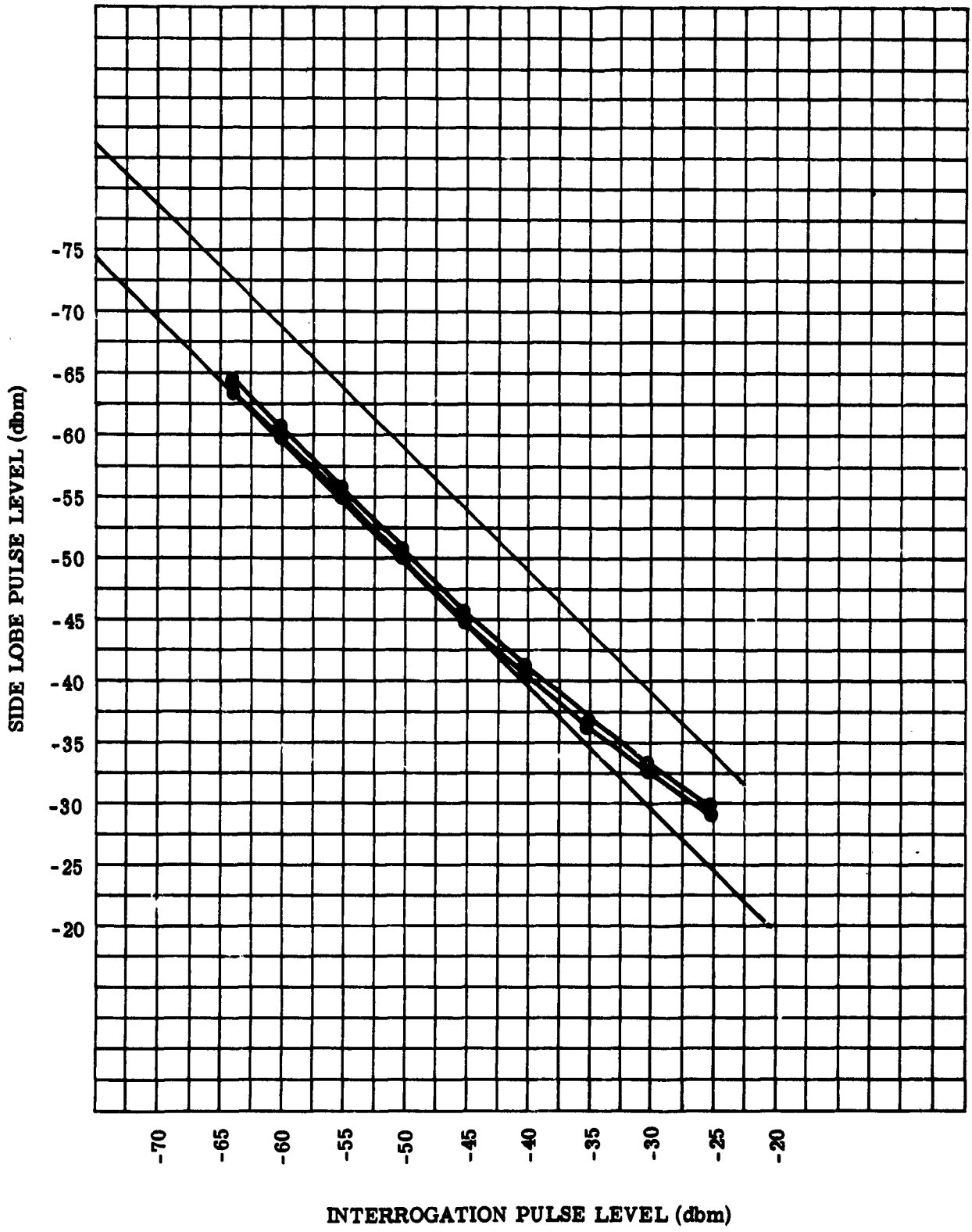
      (1) 90% reply from 7.30 to 8.48 usec
      (2) 10% reply when less than 7.26 or greater than 8.51 usec.

2. Transmitter Pulse Spacing with Reference to F1 at 500 replies per second

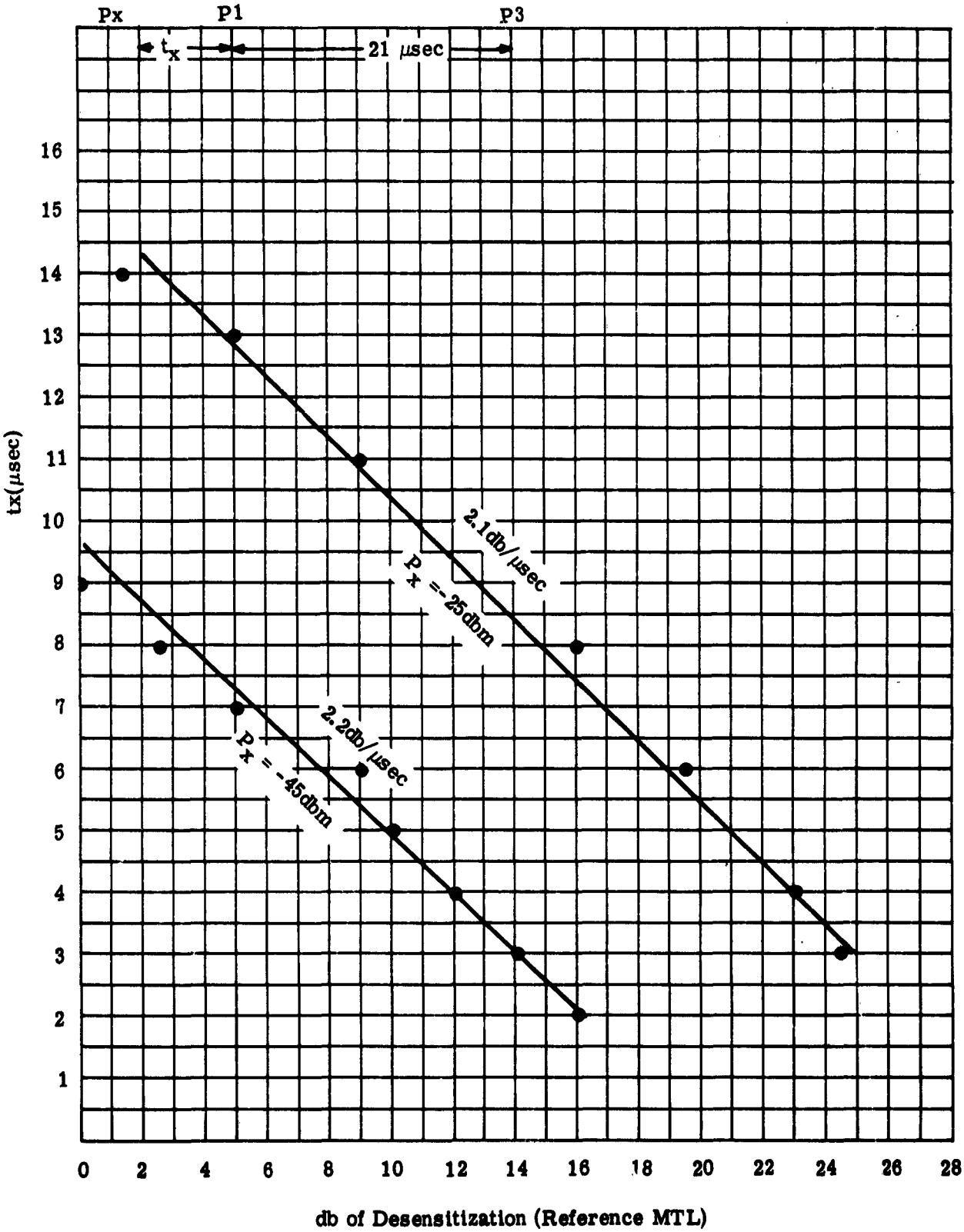
DISTANCE FROM F1		TOLERANCE DEVIATION ± .1	
A1	usec (2.9)	+ .02	usec
A2	usec (5.8)	0	usec
A4	usec (8.7)	0	usec
B1	usec (11.6)	0	usec
B2	usec (14.5)	- .01	usec
B4	usec (17.4)	- .01	usec
F2	usec (20.3)	- .02	usec
IDENT	usec (24.65)	- .04	usec



RECEIVER SELECTIVITY CHARACTERISTICS (GRAPH 22)



SIDE LOBE SUPPRESSION CHARACTERISTICS (GRAPH 23)



ECHO RECOVERY AND PERIOD (GRAPH 24)

Inst. Vibrated between Readings - No vibration during reading

Test No. 1

Test Temp. Room (75°F)

(Plug-Down Position)

Bit Change	Transit Alt. Ft.	Proper Transit Exactel #4 Reading	Actual Transit Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow Error in Ft.	(-40°C & +70°C) Extreme temps allow. error in Ft.
B4 On	-750	30.917	30.880	-.037	0.90	+33	± 60	
B2 On	-250	30.363	30.316	-.047	0.92	+43	60	
B4 Off	250	29.820	29.797	-.023	0.92	+21	60	
B1 On	750	29.285	29.272	-.013	0.93	+12	60	
B4 On	1,250	28.756	28.750	-.006	0.95	+6	65	
B2 Off	1,750	28.237	28.182	-.055	0.96	+53	65	
B4 Off	2,250	27.725	27.712	-.013	0.98	+13	70	
A4 On	2,750	27.221	27.188	-.033	0.99	+33	70	
B4 On	3,250	26.726	26.727	+.001	1.01	-1	70	
B2 On	3,750	26.235	26.195	-.040	1.02	+40	75	
B4 Off	4,250	25.752	25.743	-.009	1.03	+9	75	
B1 Off	4,750	25.277	25.265	-.012	1.05	+12	75	
B4 On	5,250	24.808	24.809	+.001	1.07	-1	80	
B2 Off	5,750	24.347	24.315	-.032	1.08	+35	80	
B4 Off	6,250	23.893	23.887	-.006	1.10	+6	80	
A2 On	6,750	23.445	23.436	-.009	1.11	+10	85	
B4 On	7,250	23.003	23.007	+.004	1.13	-4	90	
B2 On	7,750	22.568	22.545	-.023	1.15	+26	95	
B4 Off	8,250	22.140	22.141	+.001	1.17	-1	100	
B1 On	8,750	21.719	21.718	-.001	1.19	+1	105	
B4 On	9,250	21.304	21.314	±.010	1.20	-12	110	
B2 Off	9,750	20.876	20.880	+.004	1.22	-5	115	
B4 Off	10,250	20.494	20.504	+.010	1.24	-12	120	
A4 Off	10,750	20.099	20.100	+.001	1.26	-1	120	
B4 On	11,250	19.710	19.734	+.024	1.28	-30	125	
B2 On	11,750	19.328	19.338	+.010	1.31	-13	130	
B4 Off	12,250	18.951	18.970	+.019	1.33	-25	130	
B1 Off	12,750	18.580	18.596	+.016	1.35	-21	130	
B4 On	13,250	18.214	18.245	+.031	1.36	-42	135	
B2 Off	13,750	17.854	17.849	-.005	1.39	+7	140	
B4 Off	14,250	17.502	17.518	+.016	1.42	-22	140	
A1 On	14,750	17.156	17.158	+.002	1.45	-2	140	
B4 On	15,250	16.814	16.829	±.015	1.46	-22	145	

Checked by Date 6/11/62

Part No. A38391 00 001
Ser. #101

KOLLSMAN INSTRUMENT CORP.

Inst. Vibrated between
Readings - No vibration
during reading

Test No. 2

Test Temp. -40°C After 1 hr. soak at -50°C & 1 hr. soak at -40°C

(Plug-Down Position)

Bit Change	Transit Alt. Ft.	Proper Transit Exactel #4 Reading	Actual Transit Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow Error in Ft.	(-40°C & +70°C) Extreme temps allow. error in Ft.
B4 On	-750	30.917	30.895	-.022	0.90	+20		± 100
B2 On	-250	30.363	30.314	-.049	0.92	+45		100
B4 Off	250	29.820	29.803	-.017	0.92	+16		100
B1 On	750	29.285	29.274	-.011	0.93	+10		100
B4 On	1,250	29.756	28.746	-.010	0.95	+10		100
B2 Off	1,750	28.237	28.178	-.059	0.96	+56		110
B4 Off	2,250	27.725	27.704	-.021	0.98	+26		115
A4 On	2,750	27.221	27.181	-.040	0.99	+40		120
B4 On	3,250	26.726	26.703	-.023	1.01	+23		120
B2 On	3,750	26.235	26.174	-.061	1.02	+62		130
B4 Off	4,250	25.752	25.723	-.029	1.03	+30		135
B2 Off	4,750	25.277	25.232	-.045	1.05	+47		140
B4 On	5,250	24.808	24.779	-.029	1.07	+31		145
B2 Off	5,750	24.347	24.285	-.062	1.08	+67		150
B4 Off	6,250	23.893	23.851	-.042	1.10	+46		155
A2 On	6,750	23.445	23.394	-.051	1.11	+56		165
B4 On	7,250	23.003	22.969	-.034	1.13	+38		170
B2 On	7,750	22.568	22.533	-.035	1.15	+40		180
B4 Off	8,250	22.140	22.117	-.023	1.17	+27		185
B1 On	8,750	21.719	21.697	-.022	1.19	+27		195
B4 On	9,250	21.304	21.308	-.004	1.20	-4		200
B2 Off	9,750	20.876	20.858	-.018	1.22	+22		210
B4 Off	10,250	20.494	20.488	-.006	1.24	+7		215
A4 Off	10,750	20.099	20.092	-.007	1.26	+9		225
B4 On	11,250	19.710	19.744	+.034	1.28	-44		230
B2 On	11,750	19.328	19.301	-.027	1.31	+35		240
B4 Off	12,250	18.951	18.976	+.025	1.33	-33		245
B1 Off	12,750	18.580	18.603	+.023	1.35	-34		255
B4 On	13,250	18.214	18.252	+.038	1.36	-49		260
B2 Off	13,750	17.854	17.863	+.009	1.39	-12		265
B4 Off	14,250	17.502	17.472	-.030	1.42	+42		275
A1 On	14,750	17.156	17.116	-.040	1.45	+58		280
B4 On	15,250	16.814	16.786	-.028	1.46	+40		290

Checked by Date 6/11/62

Part No. A38391 00 001
Serial #101

KOLLSMAN INSTRUMENT CORP.

Inst. Vibrated between
Readings - No vibration
during reading

Test No. 3

Test Temp. Room Temp. (75°F) (After -40°C Cold Test)

(Plug-Down Position)

Bit Change	Transit Alt. Ft.	Proper Transit Exactel #4 Reading	Actual Transit Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow Error in Ft.	(-40°C & +70°C) Extreme temps allow. error in Ft.
B4 On	-750	30.917	30.888	-.029	0.90	+26	± 60	
B2 On	-250	30.363			0.92		60	
B4 Off	250	29.820	29.802	-.018	0.92	+16	60	
B1 On	750	29.285			0.93		60	
B4 On	1,250	28.756	28.755	-.001	0.95	+1	65	
B2 Off	1,750	28.237			0.96		65	
B4 Off	2,250	27.725	27.714	-.011	0.98	+11	70	
A4 On	2,750	27.221			0.99		70	
B4 On	3,250	26.726	26.726	000	1.01	00	70	
B2 On	3,750	26.235			1.02		75	
B4 Off	4,250	25.752	25.739	-.013	1.03	+13	75	
B1 Off	4,750	25.277			1.05		75	
B4 On	5,250	24.808	24.807	-.001	1.07	+1	80	
B2 Off	5,750	24.347			1.08		80	
B4 Off	6,250	23.893	23.875	-.018	1.10	+20	80	
A2 On	6,750	23.445			1.11		85	
B4 On	7,250	23.003	22.999	-.004	1.13	+4	90	
A2 On	7,750	22.568			1.15		95	
B4 Off	8,250	22.140	22.143	+.003	1.17	-3	100	
B1 On	8,750	21.719			1.19		105	
B4 On	9,250	21.304	21.312	+.008	1.20	-10	110	
B2 Off	9,750	20.876			1.22		115	
B4 Off	10,250	20.494	20.499	+.005	1.24	-6	120	
A4 Off	10,750	20.099			1.26		120	
B4 On	11,250	19.710	19.739	+.029	1.28	-37	125	
B2 On	11,750	19.328			1.31		130	
B4 Off	12,250	18.951	18.971	+.020	1.33	-27	130	
B1 Off	12,750	18.580			1.35		130	
B4 On	13,250	18.214	18.252	+.038	1.36	-52	135	
B2 Off	13,750	17.854			1.39		140	
B4 Off	14,250	17.502	17.523	+.021	1.42	-30	140	
A1 On	14,750	17.156			1.45		140	
B4 On	15,250	16.814	16.852	+.038	1.46	-55	145	

Checked by Date 6/11/62

Part No. A38391 00 001
Ser. #101

KOLLSMAN INSTRUMENT CORP.

Inst. Vibrated between
Readings - No vibration
during reading

Test No. 4

Test Temp. 70°C (After 1 Hr. Soak at 70°C)

(Plug-Down Position)

Bit Change	Transit Alt. Ft.	Proper Transit Exactel #4 Reading	Actual Transit Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow Error in Ft.	(-40°C & +70°C) Extreme temps allow. error in Ft.
B4 On	-750	30.917	30.908	-.009	0.90	+8	±	± 100
B2 On	-250	30.363	30.329	-.034	0.92	+31		100
B4 Off	250	29.820	29.828	+.008	0,92	-7		100
B1 On	750	29.285	29.289	+.004	0.93	-4		100
B4 On	1,250	28.756	28.770	+.014	0.95	-14		100
B2 Off	1,750	28.237	28.212	-.025	0.96	+24		110
B4 Off	2,250	27.725	27.742	+.017	0.98	-17		115
A4 On	2,750	27.221			0.99			120
B4 On	3,250	26.726	26.744	+.018	1.01	-18		120
B2 On	3,750	26.235			1.02			130
B4 Off	4,250	25.752	25.759	+.007	1.03	-7		135
B1 Off	4,750	25.277			1.05			140
B4 On	5,250	24.808	24.828	+.020	1.07	-21		145
B2 Off	5,750	24.347			1.08			150
B4 Off	6,250	23.893	23.902	+.009	1.10	-10		155
A2 On	6,750	23.445			1.11			165
B4 On	7.250	23.003	23.028	+.025	1.13	-28		170
B2 On	7,750	22.568			1.15		95	180
B4 Off	8,250	22.140	22.161	+.021	1.17	-25		185
B1 On	8,750	21.719			1.19		105	195
B4 On	9,250	21.304	21.332	+.028	1.20	-33		200
B2 Off	9,750	20.876			1.22		115	210
B4 Off	10,250	20.494	20.536	+.042	1.24	-52		215
A4 Off	10,750	20.099			1.26		120	225
B4 On	11,250	19.710	19.776	+.066	1.28	-84		230
B2 On	11,750	19.328			1.31		130	240
B4 Off	12,250	18.951	19.016	+.065	1.33	-86		245
B1 Off	12,750	18.580			1.35		130	255
B4 On	13,250	18.214	18.306	+.092	1.36	-125		260
B2 Off	13,750	17.854			1.39		140	265
B4 Off	14,250	17.502	17.555	+.053	1.42	-75		275
A1 On	14,750	17.156			1.45		140	280
B4 On	15,250	16.814	16.883	+.069	1.46	-100		290

Checked by Date 6/12/62

Part No. A38391 00 001
Ser. #101

Inst. Vibrated between
Readings - No vibration
during reading

Test No. 5

Test Temp. 55°C (1/2 Hr. Soak at 55°C After Dropping from 70°C)

(Plug-Down Position)

Bit Change	Transit. Alt. Ft.	Proper Transit. Exactel #4 Reading	Actual Transit. Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow. Error in Ft.	(-40°C & +70°C) Extreme temps allow error in Ft.
B4 On	-750	30.917	30.878	-.039	0.90	+35	± 60	±100
B2 On	-250	30.363			0.92		60	100
B4 Off	250	29.820	29.797	-.023	0.92	+21	60	100
B1 On	750	29.285			0.93		60	100
B4 On	1,250	28.756	28.753	-.003	0.95	+ 3	65	100
B2 Off	1,750	28.237			0.96		65	110
B4 Off	2,250	27.725	27.718	-.007	0.98	+ 7	70	115
A4 On	2,750	27.221			0.99		70	120
B4 On	3,250	26.726	26.733	+ 7	1.01	- 7	70	120
B2 On	3,750	26.235			1.02		75	130
B4 Off	4,250	25.752	25.755	+ 3	1.03	- 3	75	135
B1 Off	4,750	25.277			1.05		75	140
B4 On	5,250	24.808	24.822	+14	1.07	-15	80	145
B2 Off	5,750	24.347			1.08		80	150
B4 Off	6,250	23.893	23.889	- 4	1.10	+ 4	80	155
A2 On	6,750	23.445			1.11		85	165
B4 On	7,250	23.003	23.011	+ 8	1.13	- 9	90	170
B2 On	7,750	22.568			1.15		95	180
B4 Off	8,250	22.140	22.159	+19	1.17	-22	100	185
B1 On	8,750	21.719			1.19		105	195
B4 On	9,250	21.304	21.320	+16	1.20	-19	110	200
B2 Off	9,750	20.876			1.22		115	210
B4 Off	10,250	20.494	20.523	+.029	1.24	-36	120	215
A4 Off	10,750	20.099			1.26		120	225
B4 On	11,250	19.710	19.760	+.050	1.28	-64	125	230
B2 On	11,750	19.328			1.31		130	240
B4 Off	12,250	18.951	19.002	+.053	1.33	-70	130	245
B1 Off	12,750	18.580			1.35		130	255
B4 On	13,250	18.214	18.263	+.049	1.36	-66	135	260
B2 Off	13,750	17.854			1.39		140	265
B4 Off	14,250	17.502	17.547	+.045	1.42	-64	140	275
A1 On	14,750	17.156			1.45		140	280
B4 On	15,250	16.814	16.866	+.052	1.46	-75	145	290

Checked by Date Part No. A38391 00 001
Kollsman Instrument Corporation Ser. #101

Inst. Vibrated between
Readings - No vibration
during reading

Test No. 6

Test Temp. Room (75°F) (After 55°C Test)

(Plug-Down Position)

Bit Change	Transit. Alt. Ft.	Proper Transit. Exactel #4 Reading	Actual Transit. Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow. Error in Ft.	(-40°C & +70°C Extreme temps allow error in Ft.
B4 On	-750	30.917	30.882	-.035	0.90	+31	± 60	
B2 On	-250	30.363			0.92		60	100
B4 Off	250	29.820	29.795	-.025	0.92	+23	60	
B1 On	750	29.285			0.93		60	100
B4 On	1,250	28.756	28.750	-.006	0.95	+ 6	65	
B2 Off	1,750	28.237			0.96		65	110
B4 Off	2,250	27.725	27.712	-.013	0.98	+13	70	
A4 On	2,750	27.221			0.99		70	120
B4 On	3,250	26.726	26.723	-.003	1.01	+ 3	70	
B2 On	3,750	26.235			1.02		75	130
B4 Off	4,250	25.752	25.739	-.013	1.03	+13	75	
B1 Off	4,750	25.277			1.05		75	140
B4 On	5,250	24.808	24.807	-.001	1.07	+ 1	80	
B2 Off	5,750	24.347			1.08		80	150
B4 Off	6,250	23.893	23.876	-.017	1.10	+19	80	
A2 On	6,750	23.445			1.11		85	165
B4 On	7,250	23.003	22.994	-.009	1.13	+10	90	
B2 On	7,750	22.568			1.15		95	180
B4 Off	8,250	22.140	22.142	+.002	1.17	- 2	100	
B1 On	8,750	21.719			1.19		105	195
B4 On	9,250	21.304	21.311	+.007	1.20	- 8	110	
B2 Off	9,750	20.876			1.22		115	210
B4 Off	10,250	20.494	20.524	+.030	1.24	-37	120	
A4 Off	10,750	20.099			1.26		120	225
B4 On	11,250	19.710	19.732	+.022	1.28	-28	125	
B2 On	11,750	19.328			1.31		130	240
B4 Off	12,250	18.951	18.969	+.018	1.33	-24	130	
B1 Off	12,750	18.580			1.35		130	255
B4 On	13,250	18.214	18.247	+.033	1.36	-45	135	
B2 Off	13,750	17.854			1.39		140	265
B4 Off	14,250	17.502	17,535	+.033	1.42	-47	140	
A1 On	14,750	17.156			1.45		140	280
B4 On	15,250	16.814	16.829	+.015	1.46	-22	145	

Checked by Date

Part No. A38391 00 001
Kollsman Instrument Corporation
Ser. #101

Inst. Vibrated between
Readings - No vibration
during reading

Test No. 7

Test Temp. Room 75°F (After Vibration Tests)

(Plug-Down Position)

Bit Change	Transit. Alt. Ft.	Proper Transit Exactel #4 Reading	Actual Transit Exactel #4 Reading	Diff.	Mult. Fact.	Error in Ft.	Room Temp. Allow. Error in Ft.	(-40°C & +70°C) Extreme temps allow error in Ft.
B4 On	-750	30.917	30.869	-.048	0.90	+43	± 60	
B2 On	-250	30.363			0.92		60	100
B4 Off	250	29.820	29.778	-.042	0.92	+38	60	
B1 On	750	29.285			0.93		60	100
B4 On	1,250	28.756	28.733	-.023	0.95	+22	65	
B2 Off	1,750	28.237			0.96		65	110
B4 Off	2,250	27.725	27.698	-.027	0.98	+27	70	
A4 On	2,750	27.221			0.99		70	120
B4 On	3,250	26.726	26.700	-.026	1.01	+26	70	
B2 On	3,750	26.235			1.02		75	130
B4 Off	4,250	25.752	25.723	-.029	1.03	+30	75	
B1 Off	4,750	25.277			1.05		75	140
B4 On	5,250	24.808	24.781	-.027	1.07	+29	80	
B2 Off	5,750	24.347			1.08		80	150
B4 Off	6,250	23.893	23.862	-.031	1.10	+34	80	
A2 On	6,750	23.445			1.11		85	165
B4 On	7,250	23.003	22.982	-.021	1.13	+24	90	
B2 On	7,750	22.568			1.15		95	180
B4 Off	8,250	22.140	22.117	-.023	1.17	+27	100	
B1 On	8,750	21.719			1.19		105	195
B4 On	9,250	21.304	21.293	-.011	1.20	+13	110	
B2 Off	9,750	20.876			1.22		115	210
B4 Off	10,250	20.494	20.484	-.010	1.24		120	
A4 Off	10,750	20.099			1.26		120	225
B4 On	11,250	19.710	19.706	-.004	1.28	+ 5	125	
B2 On	11,750	19.328			1.31		130	240
B4 Off	12,250	18.951	18.946	-.005	1.33	+ 7	130	
B1 Off	12,750	18.580			1.35		130	255
B4 On	13,250	18.214	18.217	+.003	1.36	- 4	135	
B2 Off	13,750	17.854			1.39		140	265
B4 Off	14,250	17.502	17.500	-.002	1.42	+ 2	140	
A1 On	14,750	17.156			1.45		140	280
B4 On	15,250	16.814	16.834	+.020	1.46	-29	145	

Checked by Date 6/12/62 Part No. A38391 00 001
Kollsman Instrument Corporation Ser. #101